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SSTOP PROGRAM ENHANCEMENTS

Volume I

FINAL REPORT

Prepared for the
Transportation Development Centre
Transport Canada

JULY 1982

DeLCan DE LEUW CATHER, CANADA LTD.
CONSULTING ENGINEERS AND PLANNERS

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17. Abstract

The SSTOP program was developed in Canada as a tool for optimizing traffic signal timings and offsets. The main objectives of the SSTOP enhancements were to provide fuel consumption estimates, sensitivity analysis improvements, and theoretical refinements in order to increase the overall performance of the program.

The addition of fuel consumption estimates and economic analysis to SSTOP provides the user with extra measures of effectiveness in order to evaluate data which are a direct result of the timing plans.

Sensitivity analysis enhancements provide the user with greater modelling capabilities by specifying volume conversion factors and stop penalties to individual links.

Theoretical enhancements to SSTOP have increased the accuracy of the Random Delay component, which in turn will provide a more realistic estimate of potential fuel consumption savings under various control scenarios.

The SSTOP program enhancements were tested on a network of five signalized intersections. A manual review of the SSTOP output concluded that the program produced results which compare favourably with manual results based on engineering judgement and experience.

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17. Résumé

Le programme SSTOP est une méthode développée au Canada pour accroître la capacité du réseau routier et le débit de la circulation par une coordination automatique des feux de circulation. Le perfectionnement du programme initial visait à le rendre capable de faire des estimations de la consommation de carburant, à développer ses capacités d'analyse de sensibilité et à dégager les perfectionnements conceptuels susceptibles d'optimiser le rendement global de SSTOP.

Cette nouvelle capacité de faire des estimations de la consommation accompagnées d'une analyse économique permet d'apprécier l'efficacité du mode de contrôle retenu, à même les données découlant directement de l'application de celui-ci.

Le développement du programme d'analyse de sensibilité permet une modélisation plus détaillée des paramètres de coordination en variant les temps d'attente et les facteurs de conversion des débits selon la liaison considérée.

Quant aux améliorations conceptuelles, elles se matérialisent par une plus grande précision de la composante "délais aléatoires" du programme ce qui, à son tour, permet une meilleure estimation des économies d'énergie réalisables par chacun des divers scénarios envisagés.

Le programme perfectionné a été testé sur un réseau de cinq carrefours équipés de feux de circulation. Une analyse manuelle des résultats a permis de conclure que ce programme se compare favorablement à la méthode fondée sur des enquêtes in situ dans lesquelles l'expérience et l'appréciation entrent pour une large part.

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EXECUTIVE SUMMARY

Foreword

Vehicular delay and stops at signals in our urban street networks are responsible for the consumption of a significant portion of non-renewable fossil fuel. The elimination or reduction of these delays and stops through signal optimization will therefore contribute greatly to fuel consumption savings. However, this effort has been hampered by the complexity of the network optimization process, and traffic engineers have resorted to the use of computer programs as aids to signal optimization. One such program, SSTOP, has been successfully employed for signal timing and offset design. This project was initiated to enhance SSTOP as a signal optimization and evaluation tool. Through the improvement of its applicability, flexibility and accuracy, the traffic engineering community will be encouraged to increase the program's application, thus resulting in further energy savings.

1.0 Introduction

The SSTOP program was developed in Canada to produce a set of signal timings and offsets which would optimize the performance of a group of signalized intersections. The program is similar in theory to other optimization programs, such as TRANSYT and SIGOP, but has been shown to be superior in terms of user interface and coding effort.

This project has two main objectives for the improvement of the SSTOP program:

- to provide the signal network evaluation capability such that fuel consumption for existing signal timings and signal timings predicted by the program can be evaluated.
- to provide several theoretical refinements in order to increase the flexibility and applicability of the SSTOP program.

2.0 Review and Enhancements

The SSTOP Program was first reviewed and documented in detail. The following types of program enhancements were then considered:

- Fuel consumption and economic analysis
- Sensitivity analysis
- Theoretical refinements

Several theoretical features and program assumptions were investigated to determine their need for improvement.

- The lack of flow continuity between subsequent links is inherent in the program structure and is a major factor in the low running cost of SSTOP. Consequently, the feature has not been modified.

- The random delay expression does not adequately model locations which are congested. An improved expression has been installed and is described in greater detail in this report.
- The effect of opposing traffic on left turning vehicles is difficult to model using the saturation flow method. To reduce this problem, a link specific adjustment factor has been provided.
- The SSTOP program automatically deletes oversaturated intersections from the signal network. The possibility of making this feature optional was rejected because of the substantial coding effort it would entail.
- The inclusion of a link specific stop penalty will enable special link characteristics to be properly considered

3.0 Economic Analysis Enhancements

The economic analysis option in SSTOP is based on a comparison of vehicular fuel consumption levels. The fuel consumed at signalized intersections is calculated using an expression developed by Robertson[1]:

$$F_1 = k_2 D + k_3 S$$

where F_1 = fuel consumed due to signal timing (l/hr)
D = total delay in vehicle - hours/hour
S = total stops in stops/hour
k_2, k_3 = regression coefficients

The level of fuel consumed using this expression for a network improvement is compared to a 'base condition' fuel consumption to obtain the potential fuel savings. An equivalent annual fuel saving is calculated using a user-provided multiplier and this is transformed into a monetary value.

If the net present worth method is selected, the net present worth of benefits is obtained and divided by the present worth costs to obtain a representative benefit/cost ratio.

If the rate of return method is selected, a discount rate is calculated which results in the benefits of the improvement being equal to the costs.

The economic analysis option, entails no additional input if an economic analysis is not desired. This is accomplished by inputting the relevant economic data on an optional card type 7. The SSTOP output for the economic analysis option consists of a separate page following the 'TOTAL SYSTEM PERFORMANCE VALUES' table. The reductions in delay, stops and excess fuel consumption due to the network improvement are identified, as well as the annual benefits. Finally, the results of the economic analysis procedure are tabulated, for either rate of return method or net present worth method.

---

[1] Robertson, D.I., C.F. Lucas, R.T. Baker, "Coordinating Traffic Signals to Reduce Fuel Consumption", Transport and Road Research Laboratory Report 934, Crowthome, England 1980

4.0 Sensitivity Analysis Enhancements

Sensitivity analysis enhancements have been investigated for both network-wide and link specific applications. Of the possible network sensitivity factors, the most useful is the volume adjustment. The effect on network performance of variations can be identified by increasing or decreasing the volumes on all links. A second input which warrants sensitivity analysis is the phase minimum greens. Adjustment factors for two other input data types, saturation flow and clearance times, would be of marginal use. Consequently, link volumes and minimum green data were selected for the network-wide sensitivity analysis. A procedure by which individual link 'thru car unit' conversion factors could be uniquely assigned has been developed. This feature is desirable, especially for left turn volumes, as described previously. Similarly, right turn capacity is sensitive to the number of pedestrians crossing during the shared phase. Their effect as well as trucks and buses can be modelled individually for each link. The fourth parameter susceptible to link variations is the stop penalty. For example, links which include a steep gradient at the intersection approach could have a higher stop penalty than the rest of the network.

5.0 Theoretical Enhancements

As the degree of saturation approaches 1.00, the estimate of random delay predicted by Webster's expression becomes quite large, until it ceases to accurately model on-street conditions. The inclusion of fuel consumption calculations based on vehicular delay and stops necessitates accurate estimates of delay. With the initial SSTOP program, the delay can be greatly underestimated for congested intersections, thus providing inaccurate levels of fuel consumption.

This inaccuracy has been eliminated by inclusion of the random delay component used in the TRANSYT-7 program. This expression does not tend to infinity as the degree of saturation approaches 1.00, hence it can be used to model the delay effects of oversaturated intersections ($X > 1.00$). The revised random delay component for the SSTOP program will provide a more realistic estimate of potential fuel consumption savings under various control scenarios.

6.0 TRAFFIC PLANNING APPLICATION

In order to test the various SSTOP program enhancements, a small signalized network was developed. Of special concern was the ability of the SSTOP program to evaluate various traffic planning scenarios.

A recent Traffic Operations study, completed for the City of Chatham, Ontario, identified various traffic network improvements and their associated costs for a network of 5 signalized intersections. The level of benefits possible for the recommended network improvements was evaluated separately for each individual intersection. The results of this evaluation are particularly useful in identifying a priority schedule for the various network improvements, and they compare favourably with those obtained through engineering judgement based on expertise and experience. SSTOP is not only improved as a signal design model, but also made more appliable as a traffic planning tool for evaluating energy saving traffic operational measures.

1.0 INTRODUCTION

1.1 Background

With the shortage of supply and associated cost increases of motor fuel, and the objective of the Federal and Provincial Governments to reduce energy consumption, many fuel conservation measures are today receiving particular attention. The transportation system involves interaction between man, machines and the environment within an envelope of procedures represented by rules, regulations and legislation. Attention has been paid in recent years to measures that increase the fuel efficiency of the machines such as aerodynamic drag reduction devices for trucks and other vehicle component improvements for automobiles. However, the most efficient machine achieves a very low fuel efficiency when it is required to idle in a congested traffic situation or is required to change speeds frequently. The most efficient operation of an internal combustion engine is invariably in a steady state condition.

Traffic signals are designed to designate the right-of-way to particular flows of traffic at points of intersection. By their very nature they force one segment of the traffic to be delayed while a second segment of traffic is provided with the right of way. At an isolated location random arrivals can be expected and the traffic signal can assign green time to each leg of an intersection according to the demand. As additional signals are added to a street system, the interference of any signal on vehicular platoons becomes more and more acute. The opportunity arises when such a system can be designed to coordinate signals such that the flows of traffic leaving any particular intersection will arrive at a downstream intersection at the same time when the right-of-way is granted. In this way, the number of stops and total delay is reduced. As the size of the system increases, the ability of an individual traffic engineer to perform the numerous calculations necessary to optimize such a system is exceeded. Computer programs enable the traffic engineer to perform these calculations with relative ease.

A number of computer programs have been developed for signal system optimization purposes. Among these are two programs which have received prominent acclaim - TRANSYT (Traffic Network Study Tool) and SSTOP (Signal System Optimization Program). The Transyt Program, developed by the British Transportation and Road Research Laboratory, is by far the most widely used by researchers and practitioners. In Ontario, however, the SSTOP Program developed is fast becoming the adopted standard. Appendix A provides a comparison of SSTOP with TRANSYT 7, a recent version of the program, based on a number of user criteria.

The SSTOP program was developed in Canada using theory based on the RTOP Program originally developed in Metropolitan Toronto. The SSTOP development grants were given to McMaster University by the Transportation Development Centre, while the Metropolitan Toronto Traffic Control Centre staff representatives were retained as special consultants. Subsequent contracts were let to evaluate the program in Quebec City, Montreal and Cambridge. These tests revealed certain shortcomings of the SSTOP program which were subsequently corrected.

To-date, SSTOP has been used essentially as a tool for signal system optimization. However, the program has a potential for evaluating the costs and benefits of signal system improvements. Several key enhancements are necessary to improve the program to such a level that it can be used for not only signal operation but also for traffic planning purposes.

1.2 Study Objectives

This project has two main objectives for the improvement of SSTOP as a signal design and evaluation tool for improving traffic flow to conserve energy:

- to provide the signal network evaluation capability such that the fuel consumption for existing signal timings and signal timings predicted by the program can be evaluated;
- to provide several theoretical refinements in order to increase the flexibility and applicability of SSTOP.

These objectives are based on the underlying premise that as the accuracy, applicability and flexibility of the program are improved, more users in the traffic engineering community will be encouraged to apply the model for optimizing traffic flows in urban networks and thus reducing fuel consumption.

It should be noted, however, that the success of SSTOP to-date is at least partially due to the fact that it is practical, and very simple and cost-effective to use. In enhancing the program, therefore, care should be taken to retain its simplicity. The following principles should be adhered to:

1. Proven state-of-the-art theoretical models should be used for refining the program.
2. Changes to the existing coding procedure should be kept to a minimum.
3. The demand on computing time should be restricted as much as possible.

This report outlines these improvements in greater detail and provides documentation of SSTOP. Volume II, under a separate cover, contains a detailed flow chart of the program logic. Volume III consists of a source listing of SSTOP.

2.0 REVIEW AND ENHANCEMENTS

2.1 Program Documentation

The primary objective of the initial SSTOP program was to facilitate the development of coordinated signal timing plans at a relatively low cost. In order to achieve this objective, several theoretical simplifications were employed to reduce computing costs. Additionally, numerous traffic engineering assumptions were made on behalf of the user, thereby reducing the level of expertise required to run the program.

As an initial step, SSTOP was completely reviewed and fully documented. A general description of the SSTOP theory is presented in Appendix B and the program logic flow chart in Appendix C. A detailed program flow chart was also prepared and this is contained in a separate volume. The full documentation would help to simplify not only the present but also any future program modification effort.

2.2 Major Enhancements

The enhancements to be carried out on SSTOP can be divided generally into the following three areas:

1. The incorporation of a fuel consumption logic as well as an economic analysis model for the purpose of evaluating costs and benefits of signal system improvements.
2. The incorporation of a number of sensitivity analysis features, wherever appropriate, to enable SSTOP to analyze effects on signal system improvements due to variations of various system parameters (e.g., volume).
3. Theoretical enhancements to enable SSTOP to evaluate system improvements more accurately.

2.3 Theoretical Refinement Possibilities

The major theoretical simplifications and assumptions of SSTOP are described below and those which would merit improvements are identified.

Flow Continuity

SSTOP simulates the movement of vehicles from the entry point of each link to the exit point of each link. The link entry pattern is determined by the saturation flow rates of the various movements at the upstream intersection. This simplification cannot model the passage of a free-flowing vehicular platoon through the intersection after the beginning of its corresponding green phase; but rather assumes a queueing condition at the start of green. This lack of flow continuity between subsequent links is inherent in the structure of SSTOP and is a major factor in the low cost of running SSTOP. Consequently, this feature has been retained. However, the user should be made aware of its possible effects on signal timing design for undersaturated intersections. For this type of intersections, where initial queues do not normally exist, SSTOP tends to develop offsets which are ahead of the approaching free flowing platoon, thus corresponding to a higher design speed. This problem can be avoided by deleting the undersaturated signals from the network and retrofitting them after the signal settings have been processed by the program.

Random Delay

The random delay component models the effect of cyclic fluctuations in arrival volumes. Currently, a modified Webster's equation is used to determine this value. However, the expression produces unrealistically high estimates of delay when the degree of saturation exceeds .95. For this reason, any links exceeding this level were assigned a random delay corresponding to a .95 degree of saturation as a limiting condition. Consequently, this program underestimates the random delay at critical intersections.

A more refined expression of random delay is available from TRANSYT 7 and is applicable for the SSTOP model. This improved feature is described in greater detail in Section 5.

Left Turn Movement

The capacity of left turning vehicles is generally affected by the level of opposing through traffic. The use of link saturation flows to determine left turn departure rates does not adequately model left turns during gaps. This deficiency is common to all programs which employ saturation flow values (e.g., TRANSYT). Although there are many existing models dealing with left-turn capacity, none has been found to work practically and cost-effectively.

The variation in left turning capacity at different intersection approaches can be modelled, however, by the inclusion of a link specific left turn 'tcu' conversion factor. Those links with few opposing vehicles would have a low factor while those with heavy volumes would be coded with a high factor. In this manner, factors affecting left-turn capacities can be allowed for empirically.

Oversaturated Intersections

Intersections operating under a high degree of saturation are occasionally unable to operate effectively at the network cycle length under consideration. These locations are currently 'KICKED OUT' by SSTOP and allowed to operate under a longer cycle length, resulting in a loss of coordination. The benefits due to increased capacity are assumed to exceed those of maintaining coordination. However, the user may be aware of particular circumstances in the network which would make coordination a viable alternative.

SSTOP could be modified to allow oversaturated intersections to remain in the coordinated network if the user requests. However, this enhancement would entail a significant programming effort and provide only marginal benefits. Consequently, it has not been performed for this study.

Stop Penalty

A network stop penalty is entered by the user on card type 2. This transforms the number of stops on a link to an equivalent delay in order to obtain performance values. For example, a stop penalty of '4' equates one stop with four seconds of delay.

The use of a network-wide stop penalty assumes little variation among links as to the relative cost of making a stop. This approach is generally valid. However, there may be instances where the user would prefer a different stop penalty on a link. For instance, intersection approaches on a steep gradient should have a higher stop penalty in order to minimize stops. The logic used to obtain this feature is described in Section 4.

3.0 ECONOMIC ANALYSIS ENHANCEMENTS

3.1 Introduction

A user selectable option for determining potential benefits from traffic network improvements has been added to SSTOP. Annual benefits due to a reduction in vehicular fuel consumption are compared to the cost of the improvement using either the net present worth method or the rate of return method. This memorandum describes the logic for this option and summarizes the input requirements and program output.

3.2 Fuel Consumption

The determination of vehicular fuel consumption under different signal timing scenarios is a valuable tool for determining potential traffic network benefits. Several existing signal optimization computer programs contain this feature.

The TRANSYT 7F model employs a fuel consumption model developed by Robertson[1], which is based on average vehicular delay and stops at an intersection:

$$F = k_1\,TT + k_2 D + k_3 S \qquad \text{(Eqn. 1)}$$

where F = fuel consumed in litres per hour
TT = total distance travelled in vehicle-kilometres per hour
D = total delay in vehicle-hours per hour
S = total stops in stops per hour
k_i = coefficients of regression, which are functions of free speed

The traffic simulation package of TRANSYT 7F provides information concerning vehicular delay and stops at each intersection approach. Using the above expression, a representative measure of fuel consumption is calculated for each candidate signal timing plan.

In addition to computer programs which determine fuel consumption, a mathematical model has been developed by Evans and Herman[2]. Fuel consumption is determined based on average vehicular speed:

$$\phi = k_1 + \frac{k_2}{v}, \quad v \quad 35 \text{ mph} \qquad \text{(Eqn. 2)}$$

where ϕ is fuel consumption (litres per mile)

k_1 is a fuel dependent parameter associated with fuel consumed to overcome the rolling resistance and is approximately proportional to the weight of the vehicle.

k_2 is a vehicle dependent parameter (litres per hour) approximately proportional to idle fuel flow rate.

---

[1] Robertson, D.I., C.F. Lucas, R.T. Baker, "Coordinating Traffic Signals to Reduce Fuel Consumption", Transport and Road Research Laboratory Report 934, Crowthome, England 1980

[2] Evans, L. and Herman, R., "Automobile Fuel Economy on Fixed Urban Driving Schedule", Transportation Science, pp. 137-152, Vol. 12, No. 2, May 1978.

v is the average speed in kilometres per hour as measured over a distance.

The methodology has also been employed to determine vehicle emissions in networks[3], including carbon monoxide, hydrocarbons and nitrogen oxides.

Based on the above review, the following outputs from SSTOP can form a basis for determining vehicular fuel consumption:

- delay (tcu - hrs/hr)
- tcu stops per hour
- travel time (tcu - hrs/hr)
- average speed (km/h)

These values are provided in individual link and in network summary form.

Two methods of determining average link delay and stops are employed by SSTOP:

- For external links, those which do not have an upstream intersection in the network, the following expression for average delay by Webster[4], is used:

$$d = .9 \left[\frac{C\,(1-G/C)^2}{2\,(1-Y)} + \frac{X^2}{2q\,(1-X)} \right] \qquad \text{(Eqn. 3)}$$

where
d = average delay per vehicle (hours)
C = cycle length (seconds)
G = green time for the link (seconds)
X = degree of saturation (qC/sG)
q = average hourly volume (tcu/hr)
s = saturation flow (tcu/hr)
Y = volume-saturation flow ratio for the approach

Based on Eq. 3, the total hourly delay is computed as follows:

$$D = q \times d \ \text{(tcu - hrs/hr)} \qquad \text{(Eqn. 4)}$$

The proportion of vehicles (E), on external links, which are stopped at least once by the signal is given by:

$$E = \frac{N}{C\,(1-Y)} \qquad \text{(Eqn. 5)}$$

where $N = \text{Max.}\left(C-G, \frac{C-G}{2} + d\right)$

---

[3] Raus, J., "A Method for Estimating Fuel Consumption and Vehicle Emissions on Urban Arterials and Networks". Federal Highway Administration FHWA-TS-81-210, Washington, D.C., April 1981.

[4] Webster, F.V. and Cobbe, B.M., "Traffic Signals", Road Research Technical Paper No. 56, Road Research Laboratory, London, England, 1966.

The total number of stops (T) during one hour is therefore given by:

$$T = 3600 \times q \times E \qquad \text{(Eqn. 6)}$$

- For internal links, the effect of signal offsets on delay and stops is simulated using link exit histograms (Figure 1). For each offset, an arrival and departure pattern is constructed, and resultant link delays and maximum queue lengths are obtained. An additional delay value, called random delay (R), models the effect of random fluctuations in link volumes. This value is based on the second term of Webster's delay equation (Eqn. 3):

$$R = \left[\frac{X2}{4\ (1-X)} \right] \times q \qquad \text{(Eqn. 7)}$$

where x is degree of saturation

The third SSTOP output which can be used for determining fuel consumption is travel time (TT):

$$TT = \frac{L}{DS \times 1000} \times q + D + R \quad \text{(tcu - hrs/hr)} \qquad \text{(Eqn. 8)}$$

where L = link length (m)
DS = design speed (km/h)
q = volume (tcu)
D = uniform delay (veh-hrs/hr)
R = random delay (veh-hrs/hr)

Due to lack of information concerning link length and design speed, travel time is not determined for external links.

Based on DeLCan's experience, external links constitute a significant portion of many signal networks, especially urban arterials. A fuel consumption methodology which would ignore these links would be of marginal use.

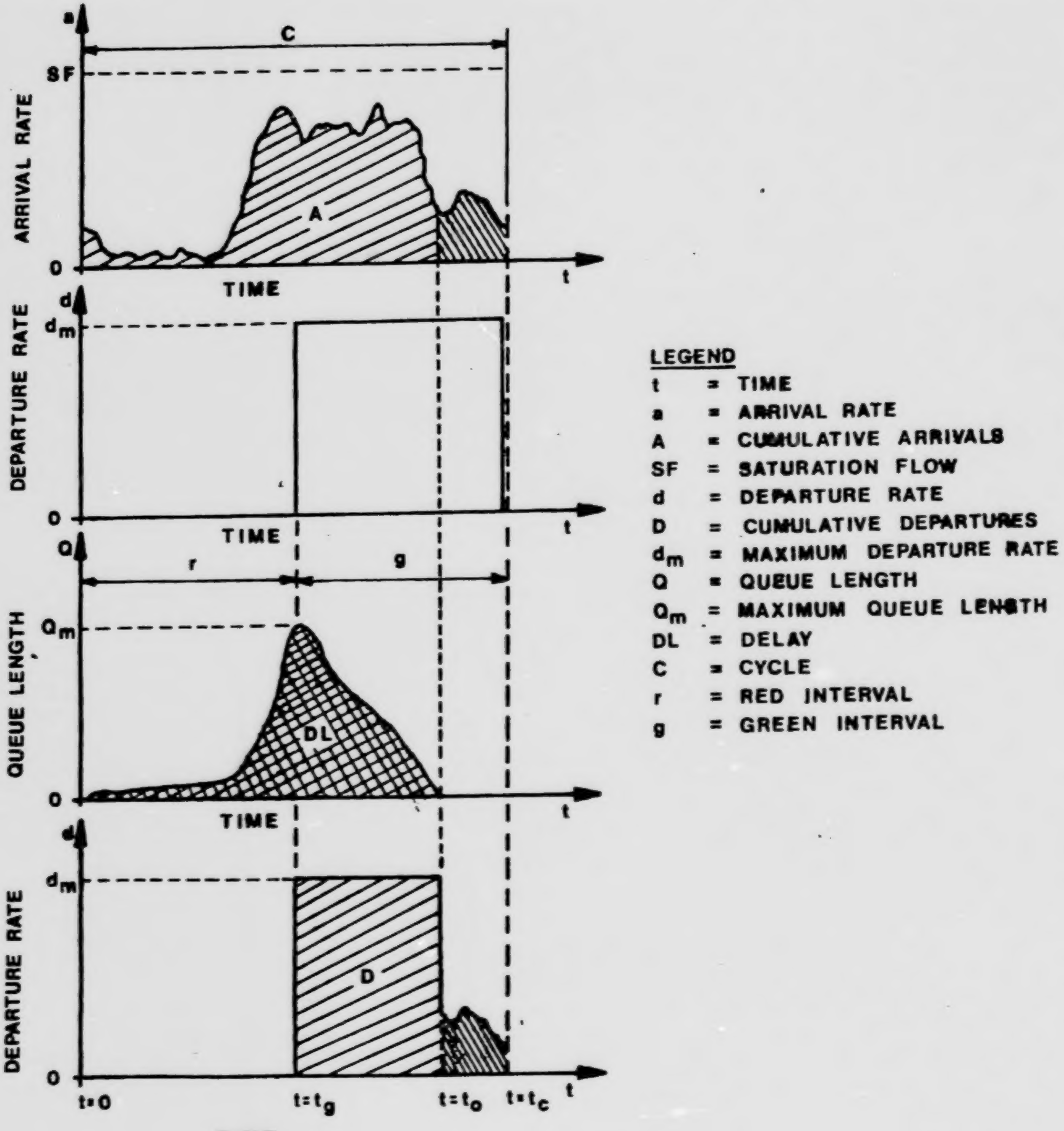
The final SSTOP produced value which can be used for fuel consumption is average speed along a link (AS):

$$AS = \frac{L \times q}{TT \times 1000} \quad \text{(km/h)} \qquad \text{(Eqn. 9)}$$

where L, q, TT are as defined above.

As with travel time, average speed can be determined only for internal links. Consequently, it is of limited use in determining network fuel consumption.

Of the four SSTOP outputs discussed, only delay and stop values are calculated for every link in the signal network. However, these parameters model the factors affecting fuel consumption at the intersection approach and cannot provide a basis for evaluating fuel consumed while travelling along a link.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d_m = MAXIMUM DEPARTURE RATE
Q = QUEUE LENGTH
Q_m = MAXIMUM QUEUE LENGTH
DL = DELAY
C = CYCLE
r = RED INTERVAL
g = GREEN INTERVAL

Figure 1 Link Departure Pattern

In view of the above deficiencies with average speed and travel time data, it was decided to utilize only delay and stops in determining fuel consumption. The fuel consumption algorithm employed by SSTOP is based on a modified form of Robertsons expression (Eqn. 1):

$$F_1 = k_2 D + k_3 S \qquad \text{(Eqn. 10)}$$

where F_1 = fuel consumed due to signal timing (litres per hour)
D = total delay in vehicle-hours/hour
S = total stops in stops per hour
k_i = regression coefficients

This expression provides a measure of the vehicular fuel consumption which is dependent on the signal timings. The additional fuel consumed while travelling along links is independent of any signal timing plan scenario and its deletion in this expression is not important for assessing various scenarios.

The optimization of signal timings will continue to be based on delay and stop measures. These measures can be made sensitive to fuel consumption by adjusting the stop penalty factor. The fuel consumption measures will be employed as an additional evaluation tool available to the traffic engineer. This approach ensures consistency with the existing SSTOP optimization methodology.

The regression coefficients used in the fuel consumption model are representative of light duty vehicles. These values are proportionate to the design speed of the individual link, as shown in Figure 2[5].

3.3 Economic Comparison

The level of improvement in the transportation network resulting from a capital expenditure is determined from the excess fuel consumed during the time period under consideration. This value is compared to a 'base condition' fuel consumption to obtain the potential fuel savings. An equivalent annual fuel saving is calculated using a user provided multiplier and this is transformed into a monetary value.

If the net present worth method is selected, the net present worth of benefits is obtained using the following equation:

$$PWB = AB \cdot \frac{(1 + i)^n - 1}{i\,(1 + i)^n}$$

Where

PWB = Present Worth Benefits ($)
AB = Annual Benefits ($)
i = Discount Rate (%)
n = Project Life (Yrs.)

The present worth benefits are finally divided by the present worth costs to obtain a representative benefit/cost ratio.

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[5] "Traffic Management Measures to Reduce Energy Consumption". Transportation Energy Management Program, Ontario Ministry of Transportation and Communications, November 1981.

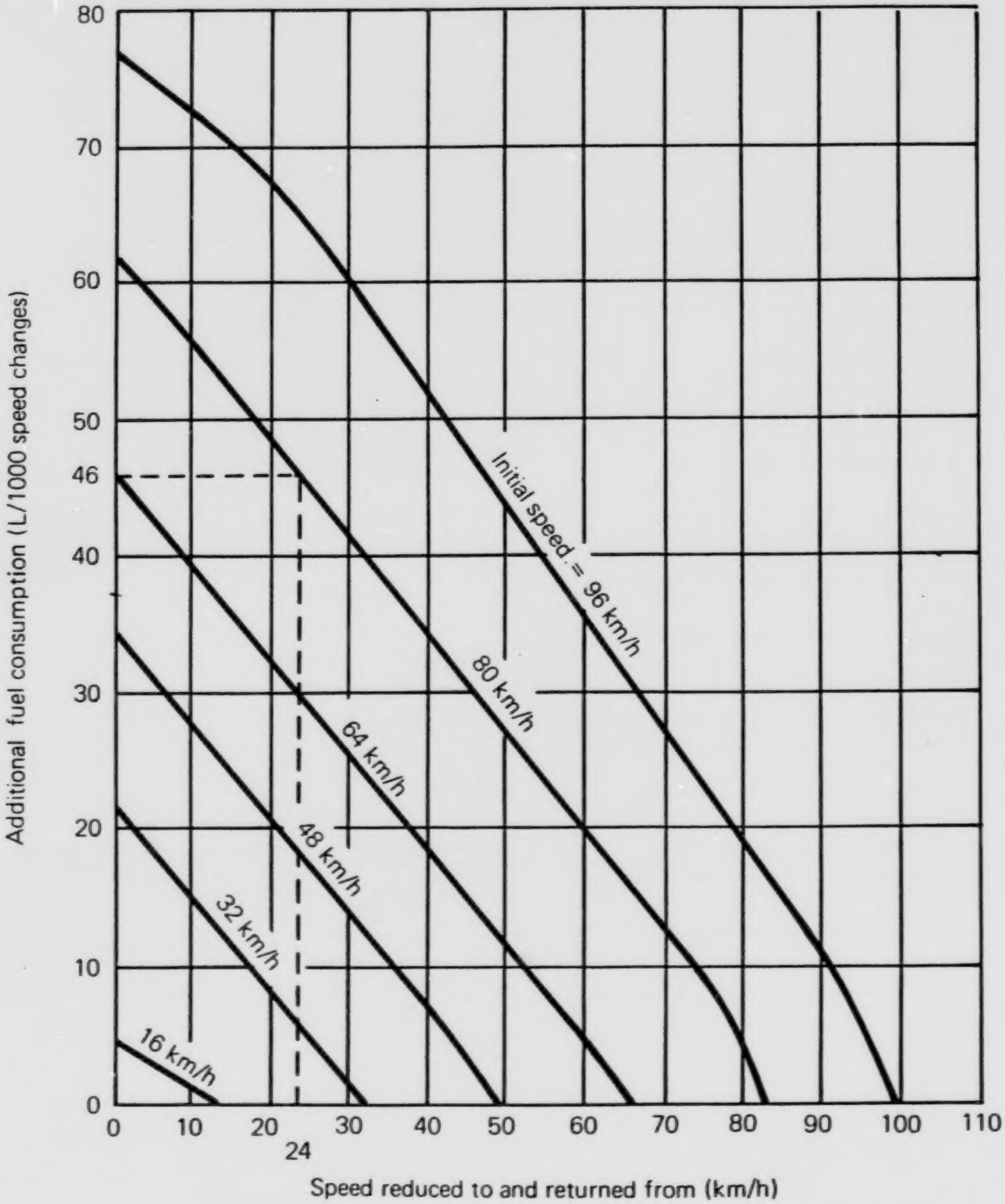


Figure 2 Additional Fuel Consumption Due to Speed Changes (for light-duty vehicles)

If the rate of return method is selected, a discount rate is calculated which results in the benefits of the improvement being equal to the costs. Beginning at a discount rate of .5%, the net present worth of benefits is calculated and compared with the net present worth costs. This comparison is repeated, at increments of .5%, until the costs exceed the potential benefits. The rate of return is identified as the highest discount rate by which benefits exceed costs.

In order to minimize the effects on the SSTOP optimization algorithm, the economic analysis option was coded primarily as a separate subroutine (ENCMC).

3.4 Input

One of the major considerations of the SSTOP enhancement project is the maintenance of the high level of user interface. With regard to the economic analysis option, this entails no additional input if an economic analysis is not desired. This is accomplished by inputting the relevant economic data on an optional card type 7.

The data required by SSTOP to perform the economic analysis are described below, including the format type and location on card type 7.

- Base Condition Delay (tcu-hrs/hr.) - the total network delay calculated by SSTOP for the traffic network without the improvement under consideration. Columns 6-10, F5.0.
- Base Condition Stops (stops/hr) - the total network stops calculated by SSTOP for the base traffic network. Although these delay and stop values are not used in the economic analysis, their inclusion can help the user in identifying other potential benefits associated with a network improvement (e.g., a reduction in stops can reduce the numbr of rear-end collisions). Columns 11-15, F5.0.
- Base Condition Excess Fuel Consumption (L/hr) - the total network fuel consumed due to signal caused acceleration/deceleration and idling for the base condition. Columns 16-20, F5.0.
- Economic Analysis Type - two alternatives are available to the user: 1 = rate of return; 2 = net present worth. Column 25, I1.
- Equivalent Annual Factor - the SSTOP optimization is generally carried out for a representative hour of traffic conditions. The fuel consumption reduction for one hour is multiplied by the equivalent annual factor to produce a yearly estimate of fuel reduction under the proposed improvement. The value of this factor must be determined by the user based on his perception of the number of hours per year where similar benefits can be obtained. Columns 26-30, F5.0.
- Project Life (years) - the number of years in which fuel consumption benefits will be obtained. Columns 31-35, I5.
- Discount Rate (%) - this value is only required when the net present worth method is selected by the user. Columns 36-40, F5.0.
- Improvement Cost ($) - the present value cost of the network improvement. Columns 41-45, F5.0.

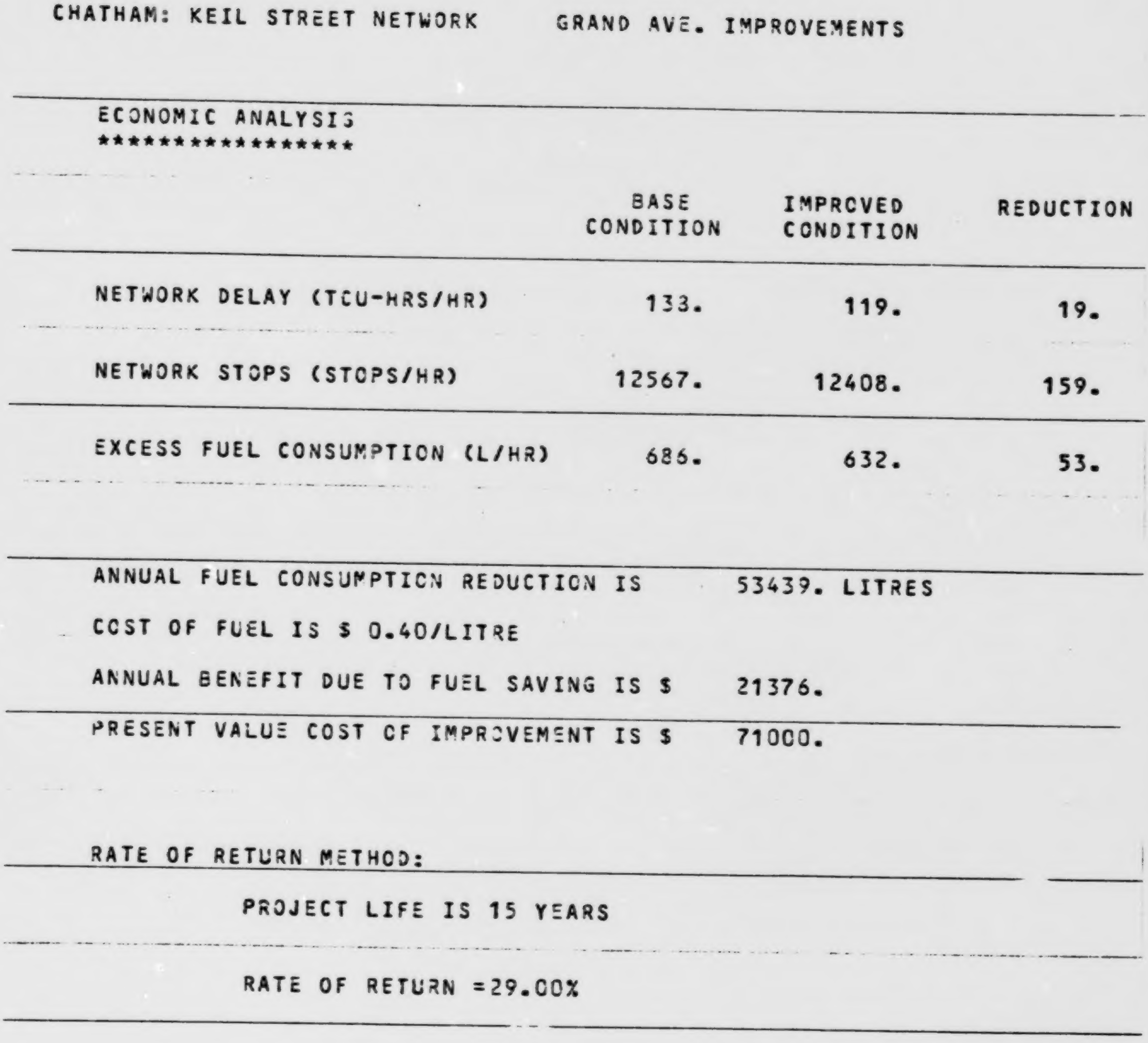
- Price of Fuel ($/L, $/gal) - the cost per unit fuel consumed is input either in terms of litres or gallons, depending on the type of units selected by the user in Card Type 2. Columns 46-50, F5.0.

Prior to signal timing optimization, the economic analysis input is checked to identify incorrect or missing information. If a deficiency is discovered, an appropriate error message is produced and the program is terminated.

It should be noted that in choosing a project life, the design life of the actual system improvement scheme under consideration should be carefully selected. While system equipment may last as long as 15 to 25 years, signal timing improvements are only in effect as long as traffic volume remains constant. To be consistent with system equipment life, the cost of regularly upgrading signal timings has to be included in the economic analysis.

3.5 Output

The SSTOP output for the economic analysis option consists of a separate page following the 'TOTAL SYSTEM PERFORMANCE VALUES' table. The reductions in delay, stops and excess fuel consumption due to the network improvement are identified, as well as the annual benefits. Finally, the results of the economic analysis procedure are tabulated, for either rate of return method (Figure 3) or net present worth method (Figure 4).



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CHATHAM: KEIL STREET NETWORK     GRAND AVE. IMPROVEMENTS

    ECONOMIC ANALYSIS
    *****************

                                          BASE        IMPROVED        REDUCTION
                                       CONDITION     CONDITION

    NETWORK DELAY (TCU-HRS/HR)            133.          119.            19.

    NETWORK STOPS (STOPS/HR)            12567.        12408.           159.

    EXCESS FUEL CONSUMPTION (L/HR)        686.          632.            53.


    ANNUAL FUEL CONSUMPTION REDUCTION IS      53439. LITRES

    COST OF FUEL IS $ 0.40/LITRE

    ANNUAL BENEFIT DUE TO FUEL SAVING IS $    21376.

    PRESENT VALUE COST OF IMPROVEMENT IS $    71000.


    RATE OF RETURN METHOD:

              PROJECT LIFE IS 15 YEARS

              RATE OF RETURN =29.00%
```

Figure 3 Rate of Return Method Program Output

```
CHATHAM: KEIL STREET NETWORK      GRAND AVE. IMPROVEMENTS

    ECONOMIC ANALYSIS
    *****************

                                          BASE       IMPROVED       REDUCTION
                                        CONDITION    CONDITION

    NETWORK DELAY (TCU-HRS/HR)              138.          119.            19.

    NETWORK STOPS (STOPS/HR)              12567.        12408.           159.

    EXCESS FUEL CONSUMPTION (L/HR)          686.          632.            53.


    ANNUAL FUEL CONSUMPTION REDUCTION IS       53439. LITRES

    COST OF FUEL IS $ 0.40/LITRE

    ANNUAL BENEFIT DUE TO FUEL SAVING IS $    21376.

    PRESENT VALUE COST OF IMPROVEMENT IS $    71000.


    NET PRESENT WORTH COMPARISON:

              DISCOUNT RATE IS 10.00%

              PROJECT LIFE IS  15 YEARS

              NET PRESENT WORTH BENEFITS = $   162584.


              BENEFIT : COST RATIO =  2.29 : 1
```

Figure 4   Net Present Worth Method Program Output

4.0 SENSITIVITY ANALYSIS ENHANCEMENTS

4.1 Introduction

A wide range of input data is required by SSTOP to develop optimum signal timings. By changing the values of the various data types, the traffic engineer can identify those which have a significant effect on the signal timing plans and performance measures.

SSTOP currently has many parameters which can be adjusted to examine program sensitivity, both on a network-wide basis and by individual links. However, adjustment factors were initially included only on a link specific basis for the following data types:

- volume
- saturation flow
- minimum greens
- clearance times

For the following parameters, only network-wide adjustments were initially possible:

- left turn tcu conversion factor
- right turn tcu conversion factor
- trucks tcu conversion factor
- stop penalty factor
- kickout cycle length

This chapter identifies those adjustment factors which would be of greatest benefits and describes the corresponding SSTOP program enhancements.

4.2 Network Sensitivity

Of the possible network sensitivity factors, the most useful is the volume adjustment. Generally, link volumes are determined from peak hour surveys, and are subject to daily and monthly variations. The effect on network performance of these variations can be identified by increasing or decreasing the volumes on all links. The volume adjustment factor can also be employed to forecast future network performance.

A second input which warrants sensitivity analysis is the phase minimum greens. These values, which are generally based on pedestrian crossing speeds, often determine the length of side street green phases. The sensitivity of the optimum network performance index to the minimum green constraints can be monitored using this policy.

Adjustment factors for the two other input data types, saturation flow and clearance times, would be of marginal use. These values are not modified except on an individual link basis, since they are dependent on the intersection configuration.

Consequently, link volumes and minimum green data were selected for the network-wide sensitivity analysis. These are optional input values which are identified on card type 5:

- Volume Adjustment Factor - this value is multiplied by the coded link volume to obtain the modified volume. Columns 36-40, F5.0.

- Minimum Green Adjustment Factor - this value is multiplied by the coded link minimum green. Columns 41-45, F5.0.

If any of these adjustment factors are selected by the user, an appropriate message is included in the 'INPUT DATA - NETWORK PARAMETERS' table.

4.3 Link Sensitivity

SSTOP obtains link volumes in terms of 'thru car units' (tcu) by multiplying left turns, right turns and trucks/buses by tcu conversion factors. The value of these conversion factors can be set by the user on a network-wide basis using card type 5. However, there was no procedure by which individual link tcu conversion factors could be uniquely assigned.

This feature is desirable, especially for left turn volumes, as described in a previous chapter. The effect of opposing through vehicles on the left turn capacity can be more accurately modelled with a link specific left turn tcu conversion factor. Similarly, right turn capacity is sensitive to the number of pedestrians crossing during the shared phase. Their effect can be modelled individually for each link.

To a lesser extent, variations occur in the effect trucks and buses have on link capacity. For example, the reduction in capacity caused by a near side bus stop can be modelled by increasing the truck/bus tcu factor for the affected link.

The fourth parameter susceptible to link variations is the stop penalty. For example, links which include a steep gradient at the intersection approach could have a higher stop penalty than the rest of the network.

Spare columns are available for these four adjustment factors on the link card type 3.

- Left turn tcu conversion factor - this value is multiplied by the left turn volume to obtain equivalent tcu volume. Columns 41-45, F5.0.

- Right turn tcu conversion factor - this value is multiplied by the right turn volume to obtain equivalent tcu volume. Columns 46-50, F5.0.

- Truck/Bus tcu conversion factor - this value is multiplied by the truck/bus volume to obtain equivalent tcu volume. Columns 51-55, F5.0. (This feature may also be used to model a change in the saturation flow value due to geometrical changes, etc.)

- Stop Penalty Factor - this value is multiplied by the number of vehicular stops and added to link delay to obtain a representative link performance index. Columns 56-60, I5.

The final possible link specific parameter is the 'KICKOUT' cycle length. Depending on individual intersection characteristics, a variation is possible in the maximum cycle length allowed. However, the present input data structure does not easily permit the identification of intersection 'KICKOUT' cycle lengths. Consequently, this factor has not been included in the sensitivity analysis option.

5.0 THEORETICAL ENHANCEMENTS

5.1 Introduction

As discussed, the majority of theoretical simplifications in SSTOP were installed to reduce computing cost and/or enhance user interface. A notable exception is the random delay component of vehicular delay at an intersection approach. This memorandum presents the initial SSTOP procedure in determining random delay and documents a more theoretically consistent approach based on the TRANSYT-7 computer program.[6]

5.2 Initial Random Delay

The random delay component of vehicular performance at an intersection was developed by Webster to model the effects of random fluctuations in cyclic arrival rates.

The Webster expression for random delay (R) is:

$$R = \frac{X^2 \quad \text{hours/hr}}{2(1-X)}$$

where X = degree of saturation.

As the degree of saturation approaches 1.00, the estimate of random delay predicted by this expression becomes quite large, until it ceases to accurately model on-street conditions.

The initial SSTOP program had a modified form of Webster's expression:

$$R = \frac{X^2}{4(1-X)}$$

The increase in the denominator constant from 2 to 4 reduces the predicted level of random delay. This was thought appropriate for a traffic network where vehicular arrivals at an intersection are controlled by an upstream traffic signal. In this environment, cyclic fluctuations in volumes are generally reduced.

A second modification to the random delay component consisted of constraining the maximum degree of saturation used in the component to .95. Consequently, for all intersection links with a degree of saturation value greater than .95, a surrogate value of .95 was used to compute random delay. This simplification does not affect the offset optimization procedure in SSTOP, but it does result in lower estimates of delay at congested intersections. A representative curve of random delay versus degree of saturation for the initial SSTOP program is shown in Figure 5.

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[6] Wallace, C.E. et al, "TRANSYT-7F USER'S MANUAL", Federal Highway Administration (FHWA), Office of Traffic Operations, Washington, D.C., December 1981.

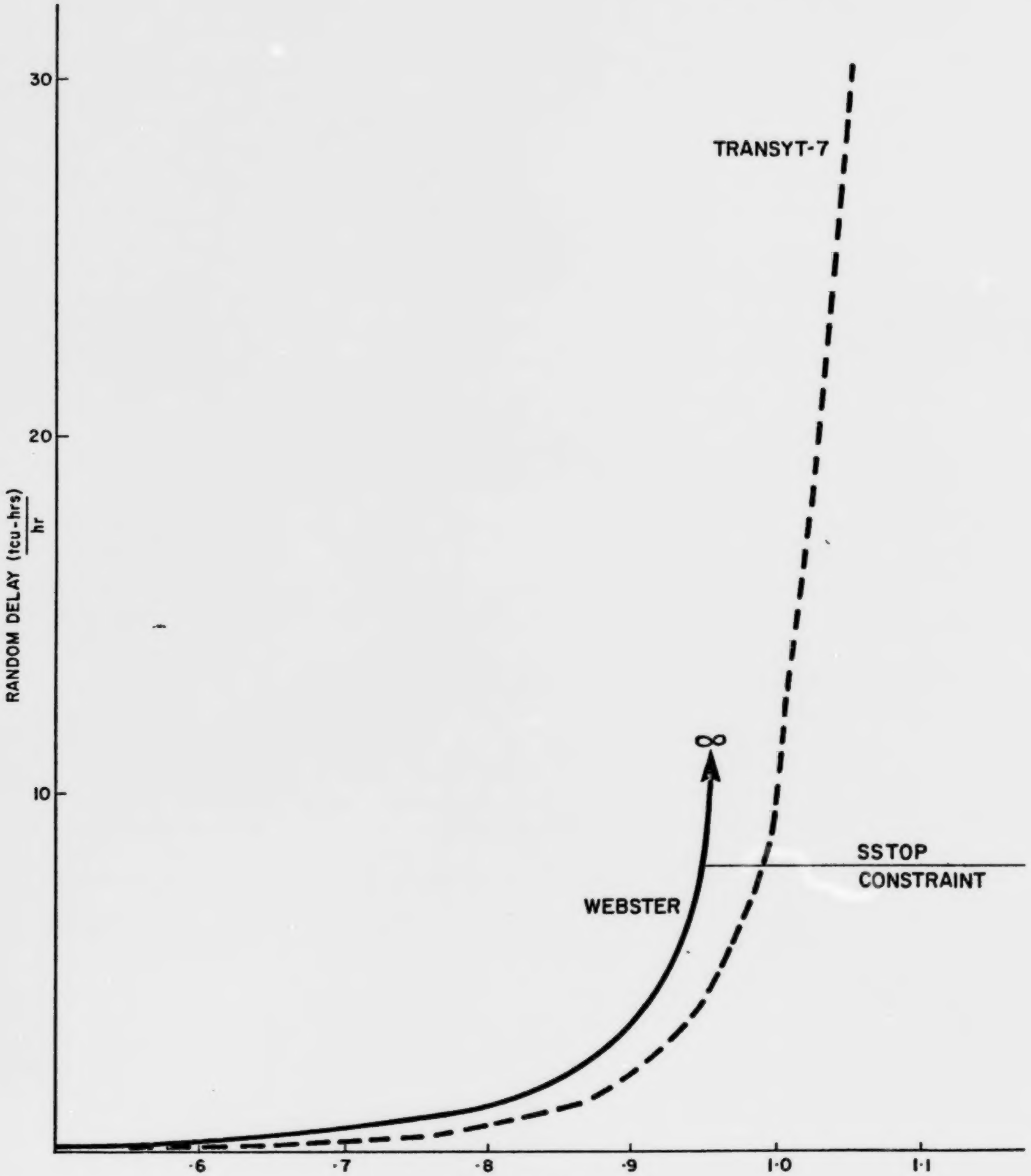

Figure 5 Effect of Degree of Saturation on Random Delay

5.3 Modified Random Delay

The inclusion of fuel consumption calculations based on vehicular delay and stops necessitates accurate estimates of delay. With the initial SSTOP program, the delay can be greatly underestimated for congested intersections, thus providing inaccurate levels of fuel consumption.

This inaccuracy has been eliminated by inclusion of the random delay component used in the TRANSYT-7 program:

$$R = \left[\left(\frac{Bn}{Bd} \right)^{2} + \left(\frac{X^{2}}{Bd} \right) \right]^{1/2} - \frac{Bn}{Bd}$$

where R = random and saturation delay
$Bn = 2(1-X) + XZ$
$Bd = 4Z - Z^{2}$
$Z = (2X/V)$
X = degree of saturation
V = volume on the link (vph)

This expression does not tend to infinity as the degree of saturation approaches 1.00, hence it can be used to model the delay effects of oversaturated intersections ($X > 1.00$). This feature is quite useful in SSTOP when highly congested intersections are forced to operate under the maximum 'KICKED OUT' cycle length.

The revised random delay component for SSTOP will substantially improve the accuracy of the vehicular delay estimate. This, in turn, will provide a more realistic estimate of potential fuel consumption savings under various control scenarios.

6.0 TRAFFIC PLANNING APPLICATION

6.1 Application Procedure

The various enhancements described in this report enable SSTOP to be used in the planning and evaluation of various traffic network improvements. Figure 6 delineates the major steps required in this area.

Although, SSTOP identifies the hourly reduction in fuel consumption for each improvement scenario, the determination of realistic economic parameters is still the domain of the traffic engineer. Critical in this regard is the estimate of the number of years during which benefits will be accrued. Changing travel patterns and/or volume increases will affect the level of benefits obtained and their effects can be modelled by the project life input.

The majority of network improvements are related to the saturation flow rate for individual links. For instance, the addition of a thru lane will be modelled by increasing the saturation flow of the appropriate link by 1800 vphg. The cost of the improvement must be expressed in present value terms to enable comparison with the potential benefits.

The final task of the evaluation is to assess the sensitivity of the best improvement scheme to variations in the various input parameters. Most important in this regard is link volumes which are subject to daily and seasonal fluctations. The effects of growth over several years can also be evaluated in the sensitivity analysis.

6.2 Description of Test Network

In order to test the various SSTOP program enhancements, a small signalized network was developed. Of special concern was the ability of the SSTOP program to evaluate various traffic planning scenarios. This section describes the test network and documents the results of the network improvement evaluation.

A recent Traffic Operations study, completed for the City of Chatham, Ontario identified various traffic network improvements and their associated costs. A small network in the west end of the city was currently suffering capacity deficiencies. This network consists of 5 signalized intersections:

- Grand Avenue and Thames Lea Plaza
- Keil Drive and Grand Avenue
- Keil Drive and Riverview Drive
- Keil drive and Richmond Street
- Richmond Street and International Harvester/Motor Wheel

The traffic operations study recommended the following improvements to this network:

- Keil Drive and Grand Avenue - an additional westbound exclusive left turn lane; additional northbound and southbound through lanes.

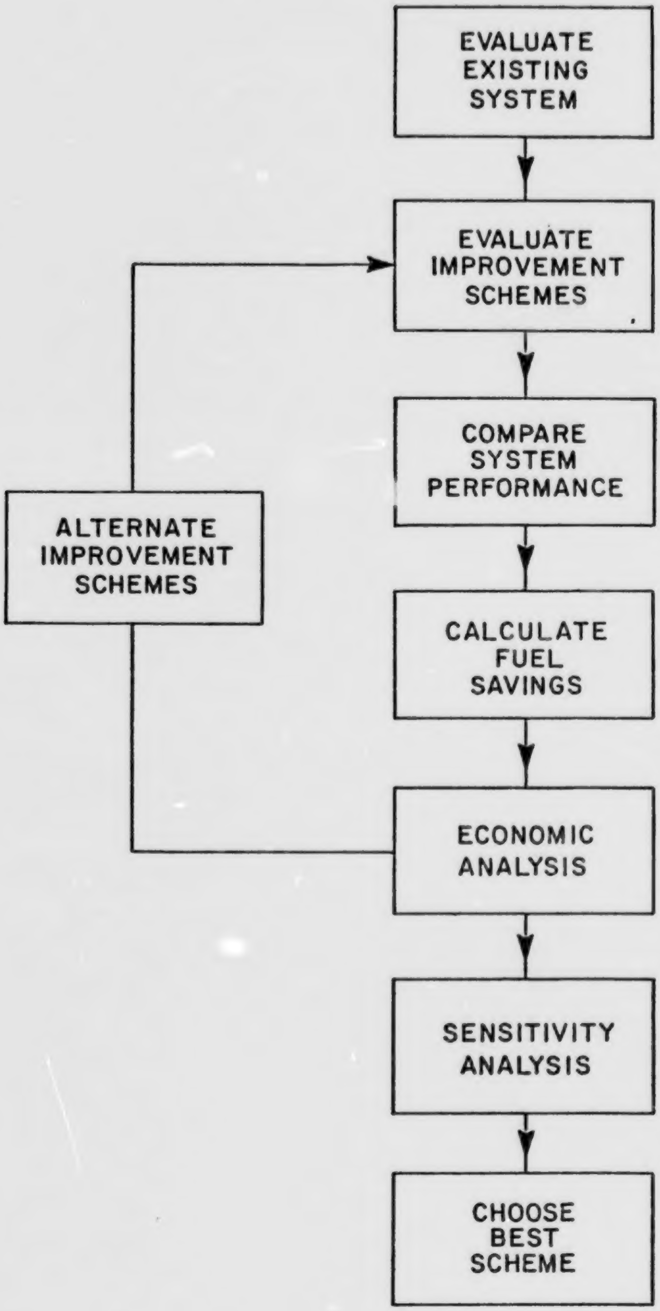
EVALUATE EXISTING SYSTEM
EVALUATE IMPROVEMENT SCHEMES
ALTERNATE IMPROVEMENT SCHEMES
COMPARE SYSTEM PERFORMANCE
CALCULATE FUEL SAVINGS
ECONOMIC ANALYSIS
SENSITIVITY ANALYSIS
CHOOSE BEST SCHEME

Figure 6 SSTOP Evaluation Model

- Keil Drive and Riverview Drive - addition of exclusive left and exclusive right turn lanes westbound and an exclusive left turn lane eastbound.
- Keil Drive and Richmond Street - an additional southbound exclusive left turn lane.

6.3 Improvement Evaluation

The first step of the network evaluation procedure was the construction of the base network. This consists of the existing geometric configuration for the five signalized intersections. SSTOP produced estimates of delay, stops and fuel consumption from the base condition for identifying potential benefits.

The level of benefits possible for the recommended network improvements was evaluated separately for each individual intersection. A project life of 15 years was assumed, with a discount rate of 10%. Figures 7, 8 and 9 summarize the SSTOP evaluation results for the three intersection improvements.

The results of this evaluation are particularly useful in identifying a priority schedule for the various network improvements. Table 1 summarizes the priority schedule identified by SSTOP in comparison with the priority assigned during the traffic operations study.

Intersection	SSTOP B:C Ratio	SSTOP Priority	Operations Study Priority
Grand	2.29	3	1
Riverview	16.15	1	1
Richmond	7.01	2	2

Table 1 IMPROVEMENT COMPARISON

Although the order of priority did not correspond exactly between the two evaluation methods, it is significant that both determined that improvements will derive substantial benefits at these locations. Consequently, SSTOP can be a valuable tool for determining the relative merits of traffic network improvements.

```
CHATHAM: KEIL STREET NETWORK     GRAND AVE. IMPROVEMENTS


     ECONOMIC ANALYSIS
     *****************

                                        BASE        IMPROVED       REDUCTION
                                      CONDITION    CONDITION

     NETWORK DELAY (TCU-HRS/HR)          138.         119.            19.

     NETWORK STOPS (STOPS/HR)          12567.       12408.           159.

     EXCESS FUEL CONSUMPTION (L/HR)      686.         632.            53.


     ANNUAL FUEL CONSUMPTION REDUCTION IS      53439. LITRES

     COST OF FUEL IS $ 0.40/LITRE

     ANNUAL BENEFIT DUE TO FUEL SAVING IS $    21376.

     PRESENT VALUE COST OF IMPROVEMENT IS $    71000.


     NET PRESENT WORTH COMPARISON:

              DISCOUNT RATE IS 10.00%

              PROJECT LIFE IS  15 YEARS

              NET PRESENT WORTH BENEFITS = $   162584.


              BENEFIT : COST RATIO =  2.29 : 1
```

Figure 7 SSTOP Evaluation Results for Grande Avenue Improvements

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CHATHAM: KEIL STREET NETWORK     RIVERVIEW IMPROVEMENTS

     ECONOMIC ANALYSIS
     *****************

                                        BASE      IMPROVED      REDUCTION
                                      CONDITION   CONDITION

     NETWORK DELAY (TCU-HRS/HR)          138.        122.          16.

     NETWORK STOPS (STOPS/HR)          12567.      10670.        1897.

     EXCESS FUEL CONSUMPTION (L/HR)      686.        606.          80.


     ANNUAL FUEL CONSUMPTION REDUCTION IS      79625. LITRES

     COST OF FUEL IS $ 0.40/LITRE

     ANNUAL BENEFIT DUE TO FUEL SAVING IS $    31850.

     PRESENT VALUE COST OF IMPROVEMENT IS $    15000.


     NET PRESENT WORTH COMPARISON:

               DISCOUNT RATE IS 10.00%

               PROJECT LIFE IS  15 YEARS

               NET PRESENT WORTH BENEFITS = $   242253.


               BENEFIT : COST RATIO = 16.15 : 1
```

Figure 8 SSTOP Evaluation Results for Riverview Street Improvements

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CHATHAM: KEIL STREET NETWORK     RICHMOND IMPROVEMENTS

    ECONOMIC ANALYSIS
    *****************

                                        BASE       IMPROVED       REDUCTION
                                     CONDITION    CONDITION

    NETWORK DELAY (TCU-HRS/HR)          138.         126.            12.

    NETWORK STOPS (STOPS/HR)          12567.       11141.          1426.

    EXCESS FUEL CONSUMPTION (L/HR)      686.         626.            60.


    ANNUAL FUEL CONSUMPTION REDUCTION IS       59904. LITRES

    COST OF FUEL IS $ 0.40/LITRE

    ANNUAL BENEFIT DUE TO FUEL SAVING IS $     23962.

    PRESENT VALUE COST OF IMPROVEMENT IS $     26000.


    NET PRESENT WORTH COMPARISON:

                DISCOUNT RATE IS 10.00%

                PROJECT LIFE IS  15 YEARS

                NET PRESENT WORTH BENEFITS = $   182254.


                BENEFIT : COST RATIO =  7.01 : 1
```

Figure 9 SSTOP Evaluation Results for Richmond Street Improvements

7.0 CONCLUSIONS AND RECOMMENDATIONS

The enhancements to SSTOP presented in this report represent a major step in ensuring the acceptance of the program for traffic planning purposes.

The modeling accuracy of SSTOP has been improved by the revised random delay expression, especially at intersections with congestion problems. Little additional computing time and costs are foreseen as a result of the improvements described in this report. This is also true with regard to the case of program understanding and interaction, since all new options have default values for the inexperienced user.

The major objectives of the project have been met in terms of program applicability and flexibility. The scope of SSTOP applications has been expanded to include:

- fuel consumption analysis
- evaluation of alternative traffic network improvements
- identification of future growth and traffic patterns on the existing road network

Program flexibility has been enhanced by the addition of several link specific and network wide adjustment factors. The experienced user will be able to use these factors to improve the performance of the traffic signal network.

Additional enhancements to SSTOP are recommended to increase the level of user interface and permit program execution on smaller sized computers.

Three separate aspects of the user interface which merit investigation are:

- Time space diagram - this option would provide vehicle progression diagrams as an optional output for user selected routes.
- Intermediate output - this feature would output detailed network descriptions to aid in the signal timing evaluation. Information would include ideal link offsets, delay profiles and link importance factors. This option would be used only by the relatively experienced users.
- Interactive Input Processor - a pre-processor computer program could be written to reduce the significant coding effort required for large networks. It would be produced by the program which would query the user for the required data and structure the results in SSTOP readable format.

A number of municipalities now have or will have traffic computers which utilize 16-bit words. In addition, small micro-computers have become more popular and the cost of such equipment is within the reach of many of the smaller municipalities. The present SSTOP program is based on a 32-bit word structure. The conversion of the program would involve substantial analysis and reprogramming in three major areas; structure, theory and accuracy.

Finally, the acceptance of SSTOP throughout Canada is contingent on a commitment to provide seminars and other educational assistance to potential users of SSTOP. These seminars would provide a background on program theory and enable hands-on experience in network coding and output interpretation.

APPENDIX A
COMPARISON OF TRANSYT 7 AND SSTOP

A.0 COMPARISON OF TRANSYT 7 AND SSTOP

The choice of a signal timing optimization program is generally based on the following criteria:

- The validity of theoretical components of the program as it affects the accuracy of the generated signal timings.
- The amount and types of input data required.
- Coding efforts.
- Processing cost in terms of machine time and other factors such as software efforts and hardware requirements.
- User interface in terms of ease of application, program understanding and output interpretation.
- Provision of special features such as multi-phase design and cycle length selection.

TRANSYT 7 and SSTOP are compared in terms of these criteria and the result is documented in the following sections:

1. Theoretical Components

TRANSYT is by far the most superior program in practice in terms of its theoretical sophistication and program accuracy. It consists of an accurate.traffic description model which is able to trace traffic flow and assesses its effects from link-to-link throughout the network, and a stable optimization model which thoroughly and systematically searches for optimum signal settings. These two factors are basically responsible for the large computing requirement of TRANSYT 5 and TRANSYT 6. In the case of TRANSYT 7, the degree of theoretical sophistication can be reduced by adjusting an accuracy parameter. If a proper value is chosen, significant computing time is saved while there is no appreciable deterioration in program accuracy.

SSTOP, however, uses a traffic model which ignores the flow continuity effect from link-to-link, and an optimization algorithm based on a random search technique. This makes SSTOP a very efficient package at the expense of program stability and accuracy. However, SSTOP has the following improvements over TRANSYT:

- Explicit treatment of split phases such as advance greens.
- Computation of optimum cycle lengths with allowance for pedestrian safety requirement.
- A more accurate platoon dispersion model for predicting the downstream arrival pattern.*

---

*SSTOP incorporates a dispersion model based on the model used in TRANSYT and calibrated for application in large Canadian urban cities.

On an overall basis, both TRANSYT 7 and SSTOP are based on similar theoretical principles, and therefore, should have similar performance potentials. TRANSYT is a well established program which has undergone a large number of field tests and many versions of enhancement. SSTOP, on the other hand, is only in its initial application stage, and therefore, minor problems are to be expected. However, all the tests performed on SSTOP to date have indicated that the program does provide reasonable signal settings. Comparisons of TRANSYT and SSTOP have provided the following general results:

- Both programs usually identify the same system cycle length as optimum.
- While the generated settings for individual signals may differ, both programs converge to similar degrees of optimization for the entire network.
- SSTOP is generally less accurate in evaluating signal settings. (This is due to the lack of flow continuity treatment as explained earlier).

In summary, both SSTOP and TRANSYT 7 are regarded as equally effective as a signal design tool where only relative merits of signal timings have to be accurately determined. As an evaluation model, where absolute values of delay and stops are required, TRANSYT 7 is the more superior program. For this reason, delay and stops generated by SSTOP should not be expected to match on-street measurements exactly. In any case, both programs are only signal design computing aids and their effectiveness is ultimately dependent on sound engineering expertise and judgment in their execution, application and interpretation.

2. Data Requirement

Both SSTOP and TRANSYT 7 are basically similar in terms of data requirement. Although there are minor differences, these are not significant enough to influence the choice of the user. Whichever program is chosen, it is important that reasonably accurate data be provided as input in order that effective signal timings can be obtained.

3. Coding Efforts

Although the effectiveness of a program in terms of on-street performance is a major concern, the manpower requirement for input coding is also an important consideration for the practicing traffic engineer. Comparative data on the coding efforts for TRANSYT 7 and SSTOP are not directly available, but it was found in the Improved Operations of Urban Transportation System Study in Toronto that, for a network of a given size, TRANSYT 5 required more coding effort than the RTOP program, the real-time predecessor of SSTOP, by 27%, 25% and 13% of a senior engineer's, junior engineer's and technician's time, respectively. The amount of coding effort at the technician level required by TRANSYT is reduced somewhat through the introduction of the latest version TRANSYT 7, but the amount of supervision by senior personnel remains high compared to SSTOP, which is a general reflection of the higher level of theoretical sophistication required on the part of a TRANSYT user. An evaluation option incorporated in the SSTOP model does increase the coding effort required to run SSTOP when the option is selected. However, this increase, in the order of approximately 10%, would not significantly alter the present imbalance of coding effort when compared to TRANSYT. An additional point in favour of SSTOP is that a large number of candidate system cycle lengths can be processed by SSTOP for the same amount of coding, while in the case of TRANSYT 7, added coding effort is required for processing additional cycle lengths. Similarly, SSTOP is significantly more convenient than TRANSYT 7 if the network in question is to be reconfigured slightly by adding or deleting certain signals and/or links.

4. Processing Requirement

Both SSTOP and TRANSYT 7 are regarded as medium size programs which normally require a medium to large 32-bit word computer. SSTOP requires about 120 k bytes, while TRANSYT 7 requires 180 K. With some re-programming effort, SSTOP can be modified to run with as low as 52 K bytes of memory at the expense of computing time. Both programs use card input and paper output, but SSTOP has been designed with allowance for CRT format restrictions and so a CRT screen can be used as an input-output device with little or no software conversion effort. There should also be no difficulty in installing either program on any IBM compatible 32-bit word computer, but considerable software efforts are required if a 16-bit word computer is to be used.

One major advantage SSTOP has over TRANSYT is its efficiency in terms of computing time requirement. During the SSTOP conversion study in McMaster University it was found that for a network of 29 signals and 103 links, SSTOP required 87 seconds of CPU time for processing 6-cycle lengths on a CDC 6400 computer, while TRANSYT 6 needed 240 CPU seconds for only one cycle length. The difference becomes more drastic as the size of the network increases since the computing time for TRANSYT 6 varies exponentially with the number of links in the network while that for SSTOP varies linearly.

With a speedier optimization procedure, TRANSYT 7 requires much less processing time than TRANSYT 6, depending on the value of the accuracy parameter chosen. As in the case of SSTOP, the computing time for TRANSYT 7 varies linearly with the number of network links. However, it is still slower than SSTOP by a 5.5:1 ratio.

5. Special Features

In addition to normal features common to both programs, TRANSYT 7 also provides the following:

- Reoptimization of calculated splits after offset optimization for system improvement.
- A shared stop-line feature which allows the treatment of special movements such as bus priority.
- Treatment of non-signalized bottlenecks.
- Calculation of delay at over-saturated locations (but they are not isolated from the system as in the case of SSTOP).
- Scaling of volume and speed input for sensitivity tests.
- Optional graphical output showing stop-line flow patterns to illustrate progression characteristics.

SSTOP, however, has the following additional features:

- A special split-computation procedure for intersections with split phases.
- Calculation of different candidate cycle lengths, based on capacity and pedestrian safety criteria.
- Network restructuring by isolating signals with higher cycle requirement.
- Automatic comparison of different cycle lengths within the same computer run.

The determination of vehicular fuel consumption under different signal timing scenarios as featured in both TRANSYT and a recently improved version of SSTOP. Both these programs employ the same fuel consumption model which is based on average vehicular delay and stops at an intersection. Hence, no differentiation exists between the programs in this respect.

It can be concluded from the above comparison that while TRANSYT 7 is more versatile and more suitable for research and evaluation purposes, SSTOP is a more practical model for signal timing design.

6. User Interface

For the practitioner, the most important aspect of a signal optimization program is, perhaps, its interface with the user. A program which is easy to use tends to encourage frequent application and hence regular signal timing updates. This often more than compensates for any other program deficiencies. In comparison with TRANSYT 7, SSTOP has an extremely attractive user interface package with the following features:

- The User's Manual is concise and easy to follow.
- The coding procedure is simple and can be learned quickly by inexperienced personnel.
- The output is comprehensive and in English form, readily understood by an average user.
- The program contains many practical features which tend to instill confidence in the user.
- The provision of a number of automatic and convenient features reduces re-coding and computer rerun to a minimum.

APPENDIX B
GENERAL DESCRIPTION OF SSTOP
(EXCERPT FROM SSTOP USER'S GUIDE)

B.O THE PROGRAM SSTOP

During the Improved Operation of Urban Transportation Systems (IOUTS) research and development study, four existing offline signal system optimization algorithms were evaluated in depth. Based upon experience gained from this evaluation, as well as a review of existing signal timing strategies, a Real-Time Optimization Program (RTOP) for traffic signal networks was written and tested on-street. The RTOP program was constructed in modular form, by extracting what were considered to be the best signal timing components from the available packages, and restructuring them to produce an effective real-time program for computerized traffic signal networks.

The research effort undertaken by the Traffic Research Group at McMaster University was an extension of the IOUTS work. In addition to the changes necessary for conversion of the real-time program to an offline version, the input and output sections were rewritten to meet the particular requirements of this study. Furthermore, several major additions were made to the basic framework of the real-time program which add to the versatility and flexibility of the offline optimization program SSTOP.

The following sections of this chapter include a very brief overview of the program and are intended to provide the user with a basic understanding of SSTOP operation prior to dealing explicitly with the input and output requirements associated with an actual application.

B.1 Input-Output Outline

Data input requirements for SSTOP have been limited to those items which are normally required for manual generation of a signal timing plan or which can be otherwise easily obtained. Transfer of data to SSTOP is made through the use of four card types, with a fifth type being optional. One Type 1 card provides a run title to the program, while the one Type 2 card specifies a variety of network or global parameters. Card Types 3 and 4 supply SSTOP with the detailed signal, traffic and geometric characteristics of the network which are required for the optimization process. Although default values for several parameters have been included in the program, an optional card Type 5 may be used to alter those values if desired. End of data is signified by placing a card with 9's punched in the first five columns at the end of the data deck.

The output is structured so that users may easily inspect input parameters and evaluate resulting signal settings. Various link and system performance values including degree of saturation, uniform and random delay and travel time are provided to facilitate this evaluation process. The network signal settings are presented in a format which facilitates easy field implementation.

B.2 Program Operation and Theory

The first operation of SSTOP is to read in, check and sort the input data. Checks in the following areas are made:

a) input data cards occur in the proper sequence?

b) the correct number of each card type has been supplied?

c) the size of the network does not exceed program capabilities?

d) correct number of links and intersections specified on the card types?

Violation of any of these consistency checks will result in printing of a diagnostic message, followed by program termination. Several non-fatal messages may also be printed, but these should prove self-explanatory.

An optional data check which is particularly useful for data card decks being used for the first time is also available. This option allows the user to ensure that all integer data fields on card types 3 and 4 contain only numeric or blank entries. Comparison testing, i.e., ensuring that specified parameter values fall within an acceptable range (e.g., volume greater than 10, less than 2000) is not performed. Although the user must ensure that all entries are within an acceptable range, such checks may be coded into the program with little effort.

Upon completion of these tasks, the data for each individual signalized intersection is considered and a number of possible cycle lengths are calculated on the basis of the following design criteria:

a) Absolute minimum cycle length: the cycle length at any signal must not be less than the aggregate minimum pedestrian walk time and clearance interval requirements for each phase.

b) Webster's cycle calculations: two cycle length values are calculated based on Webster's Method to satisfy the capacity restraints. One is the minimum cycle length necessary to provide adequate capacity, and the other is the practical minimum cycle length which allows for an additional 10 percent capacity to cope more efficiently with random traffic fluctuations.

c) Minimum green cycle calculations: considering both the minimum green requirement and vehicular flows for each phase, two cycle length values are calculated. One provides the minimum green time necessary to provide adequate capacity for each phase (including constraints), and the other, the practical minimum green time necessary to provide a 10 percent reserve capacity for each phase. This set of calculations ensures that the green times for each link calculated in b) above are not less than specified minimums.

Based upon the above computations, two final cycle lengths are identified for each individual signalized intersection; one a practical minimum, and the other, a practical optimum. Both selected cycle lengths have a minimum allowable value equal to the absolute minimum cycle length, as defined in a) above. In any case, the minimum allowable cycle length selected by the program may not be less than 40 seconds. Also, neither of the two final cycle lengths will be less than the minimum system cycle length specified on Card Type 2. Neither of the selected cycle lengths will exceed the Maximum Kickout Length specified on Card Type 2.

As an integral part of the above analysis, the signal splits for each of the possible cycle lengths are calculated, based on Webster's method by setting the green times proportional to their respective volume/saturation flow (V/S) ratios. Should any signal be oversaturated, that is, the sum of the critical V/S ratios exceed 1.0, a message is printed and the program terminated.

Inherent in the split calculation is a unique procedure by which the operation of advanced or delayed greens are explicitly accounted for. Briefly, SSTOP calculates the green time necessary to service the left-turning vehicles, assuming that a given number of these may be cleared during the amber period. The solid green period for the through movements and right turns is then calculated, recognizing that a number of the through and right-turning vehicles on the approach with the advanced or delayed green have also cleared during the priority green period. The user must determine which locations require a priority green prior to network coding.

After the signal timing computations have been completed for each individual intersection in the network, the timing information along with the link approach volumes and their related saturation flows are stored for subsequent network analysis. For overall network control, up to ten specified candidate system cycle lengths are evaluated to identify the 'best' cycle length for the system. To reduce computing time requirements, SSTOP performs some calculations using two second increments. For this reason, odd-numbered cycle lengths should be avoided as they do not result in an integer number of steps. Generally, SSTOP tends to treat odd-numbered cycle lengths similar to the next lower even-numbered cycle length. Although a two second increment between trial cycle lengths is possible, it is recommended that a ten second cycle length increment and an even valued minimum trial cycle length be used (e.g., minimum trial cycle length = 64 seconds), as this allows every trial cycle to be divided into an integer number of steps.

For each candidate cycle length, the following general functions are then performed:

a) Intersections which will be placed under coordinated control in the system and those which will be isolated from the system are identified. Whenever the candidate system cycle length is less than the required individual minimum cycle length at an intersection, that intersection is placed under isolated control.

   This particular operation is performed by the 'KIKOUT' subroutine. If an intersection is identified as not being capable of operating effectively at the trial cycle length due to either minimum pedestrian requirements, capacity considerations or minimum vehicular green requirements, it is 'removed' from the network, and thus, offset optimization is not performed on that signal. The isolated signals are allowed to operate at their optimum cycle lengths, thereby avoiding the possibility of oversaturated signals in the network. The optimum cycle length for any kicked out signal is less than or equal to the 'Maximum Kikout Cycle Length' which is required as input on Card Type 2. If the specified value is too low, it is possible that a kicked out signal may be oversaturated, in which case SSTOP underestimates delay and stop values for this signal.

   Should there be no coordinated signals remaining after this operation, a message is printed. The next trial cycle is then processed with no further analysis being performed for the present trial cycle length. While performance of the isolated signals is evaluated separately from the remainder of the network, a total performance value is computed by combining the performance indices for both the isolated and coordinated signals. This allows the user to determine whether the network operates most efficiently at a lower cycle length with one or more isolated signals operating at higher cycle lengths, or whether the entire network should be operated at some higher value.

b) Calculation of the signal timing intervals for both the coordinated and the isolated signals in the network: A maximum of six green intervals per intersection is allowed. A split phase consisting of a priority green and a solid through green consists of two green intervals.

c) Computation of delay/difference-of-offset relationships for the coordinated signals in the network: First, link entry flow patterns are generated using the signal and volume data from the upstream signal. Generally, a single link is sufficient to represent an approach leg in the network. In certain cases however, the single link representation is inadequate. Therefore, provision is made within SSTOP to allow a given section of roadway connecting two signals to be represented by two or more links. These links are termed parallel links. For parallel links it is assumed that the shape of the link entry flow curve is identical for both links. The magnitude of the curve for each of the links is dependent upon the ratio of their exit volumes. Thus, if link A accommodates 70 percent of the total approach volume, its link entry flow curve will be seven-thirds as great as that of link B, but, as previously indicated, it will have the same shape.

   Link exit flow patterns are then formed at the downstream signal. Allowance is made for the effect of dispersion of the traffic platoon as it travels downstream along the link, using Robertson's platoon dispersion model. Finally, for every offset difference between the upstream and downstream signals, a pair of delay and stop values is computed from the arrival and departure patterns at the link exit signal, based on the logic adapted from the GLC-Combination Program. The above delay value accounts only for the effect of coordination and does not allow for capacity constraints, thus rendering the value inappropriate for cycle length comparison. Therefore, to complete the delay computation, a random delay component is included which takes into account the delay caused by random fluctuations in the traffic volume. The random delay component is a function of the degree of saturation only, as described by Robertson. Thus, an approach represented by two parallel links will have two random delay calculations, whereas if it was represented by a single link, it would only have one. If the degrees of saturation on the parallel links were equal, then the approach with the parallel link representation would have twice as much random delay attributed to it as the same approach with the single link representation. A parallel link representation of an approach may therefore tend to overemphasize the random delay component. An upper bound of approximately 4.5 hrs/hr of delay is set for all internal, non-kicked out links.

d) Identification of the ideal offset for each link: A performance index is computed for each given offset difference between the upstream and downstream signal. This performance index is based on the amount of uniform delay, the amount of random delay, and the estimated number of stops resulting from any particular offset difference. The best offset difference for the pair of signals in question is the one given by the minimum performance index.

e) Calculation of link importance factor: The importance of a link is analogous to the sensitivity of its performance towards the choice of offset difference. For a highly important link, an offset close to the ideal value should be implemented, whereas for an unimportant link the use of the ideal offset is not essential. These importance factors are derived from the link performance curves. Using this importance factor, the links are ranked between one and one hundred, giving an indication of the relative importance with respect to the most critical link in the system. Provision is made in the input data to allow specification of a link importance factor multiplier which is multiplied by the link importance factor before ranking.

f) Offset Optimization: Using a technique adapted from the SIGRID Program, the optimum offsets, as given by the offset values associated with the global minimum system performance function, are calculated. It should be noted that this function merely measures the discrepancy between the ideal and calculated offsets, and not the real system performance in terms of delay and stops. However, it does provide a relative indication for performance comparisons of different offset arrays for a given trial system cycle length.

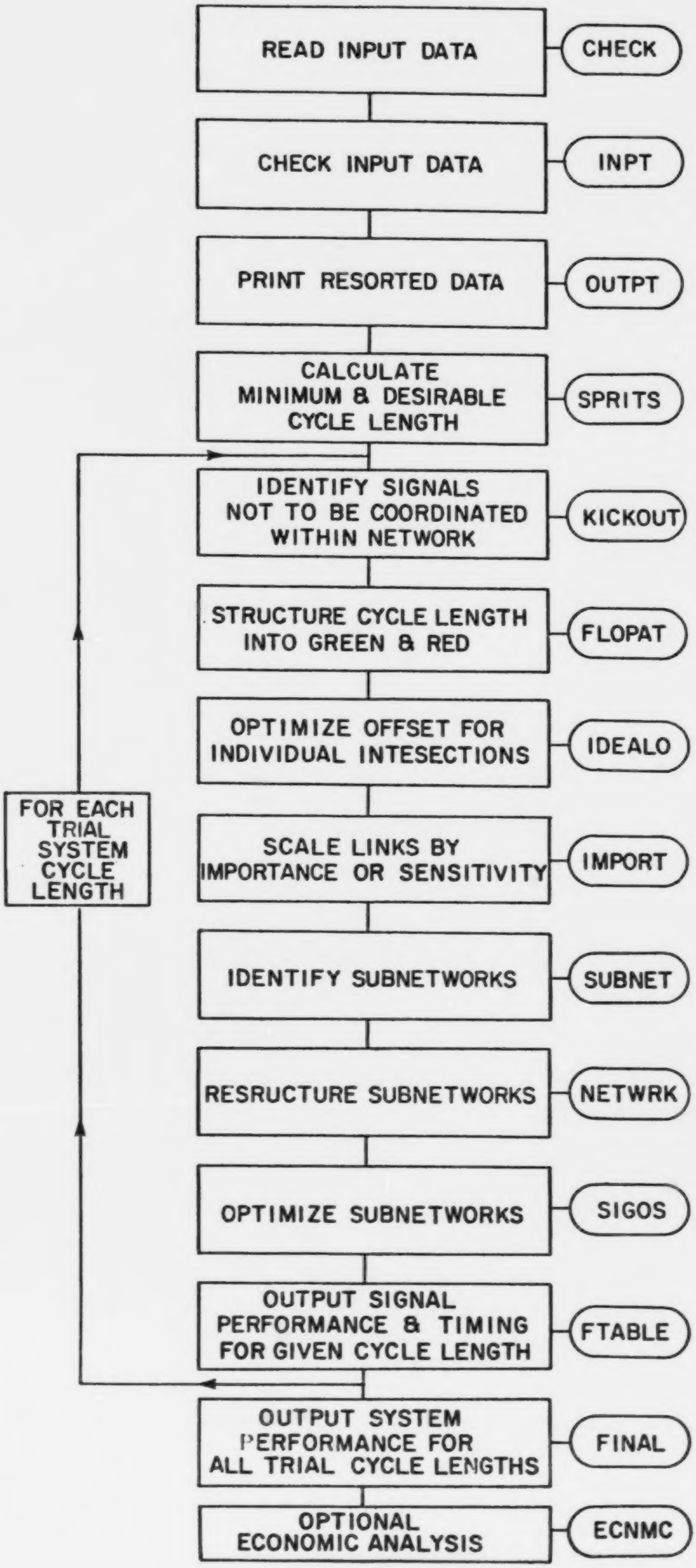
g) Evaluation of the performance of isolated signals: This is accomplished in terms of delay and stops using the technique developed by Webster. An upper bound of approximately 8.2 hrs/hr of random delay is set for the links associated with kicked out signals. External links also have an upper bound of 8.2 hrs/hr of random delay, while all priority left-turn links have an upper bound of 3.65 hrs/hr. Uniform delays and stops for these links are also evaluated using Webster's method. All priority green links, external links and internal links emanating from or entering kicked out signals are processed in this section.

   Delays and stops for internal, non-kicked out links are obtained by referencing the delay/difference-of-offset curves previously calculated. As previously mentioned, these have a maximum random delay of approximately 4.5 hrs/hr. It is important to remember that all delay and stop values are considered relative indicators and are not necessarily measures of actual on-street performance.

h) System Performance Evaluation: The overall system performance index is obtained by adding the performance index from the isolated signals and the performance index of the coordinated signals. The performance index is a function of both the stops and delays on each link. Following each trial cycle length, the optimum splits and offsets are printed for each intersection, as are individual link performance indicators. After the entire range of candidate system cycle lengths has been processed, a table of total system performance values are printed with the optimum cycle length.

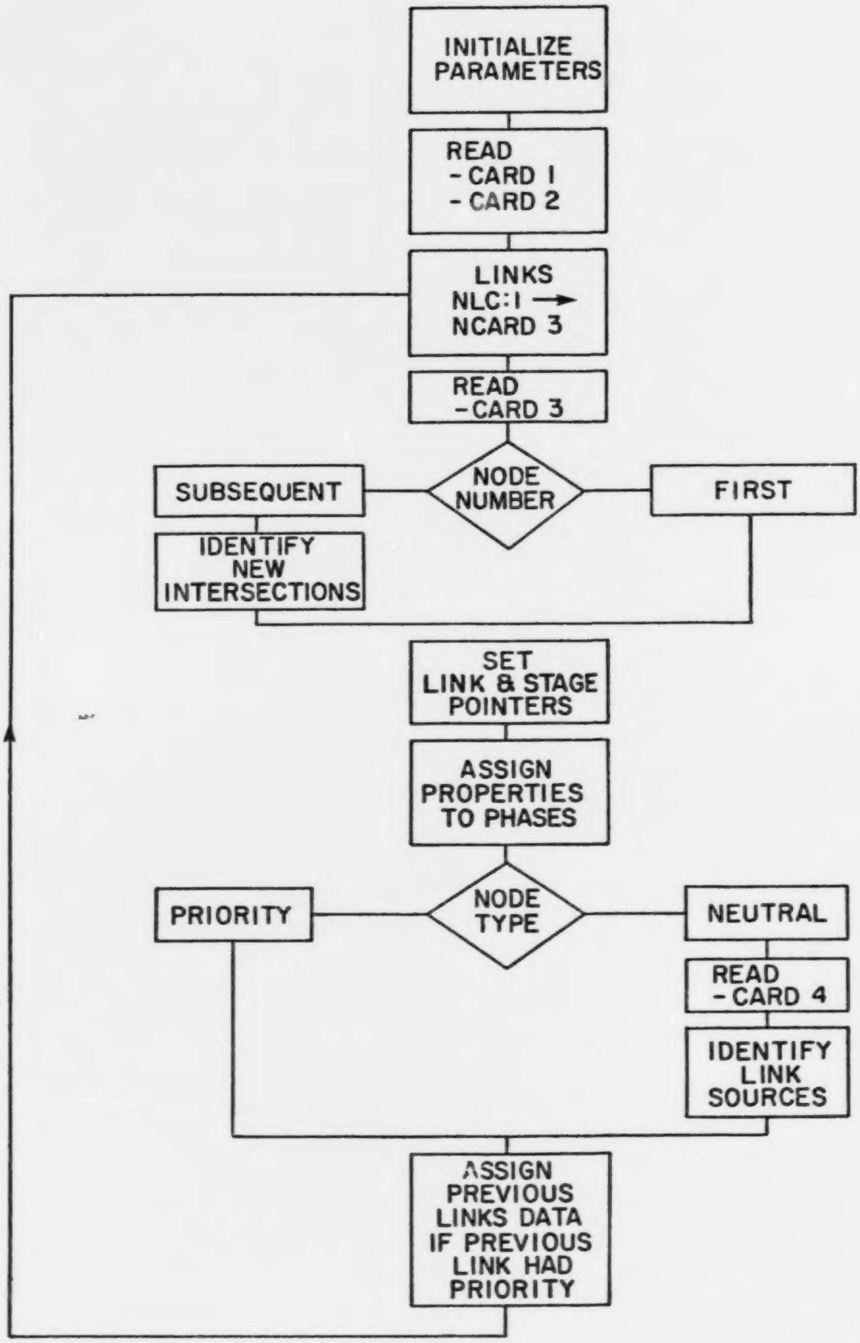
APPENDIX C
GENERAL PROGRAM LOGIC FLOW CHART

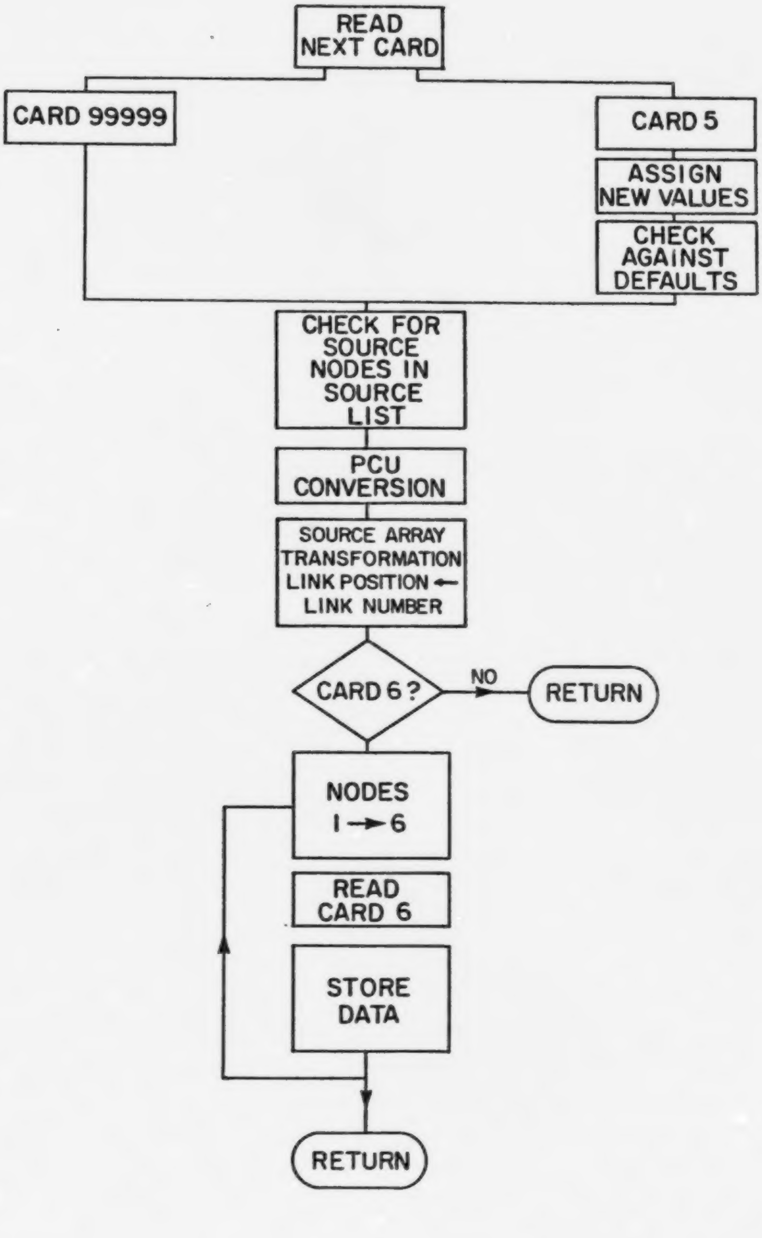
SSTOP



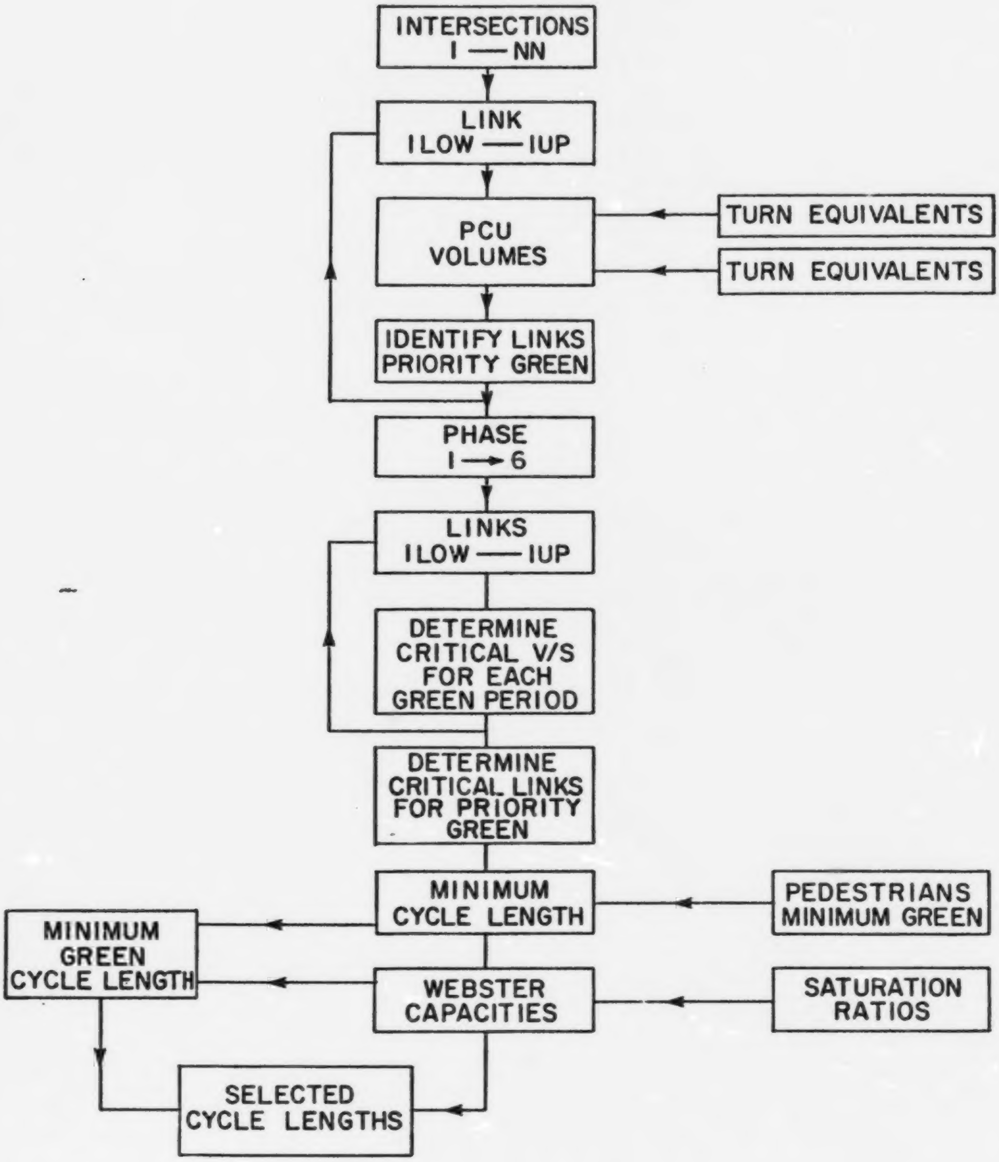
READ INPUT DATA
CHECK
CHECK INPUT DATA
INPT
PRINT RESORTED DATA
OUTPT
CALCULATE MINIMUM & DESIRABLE CYCLE LENGTH
SPRITS
IDENTIFY SIGNALS NOT TO BE COORDINATED WITHIN NETWORK
KICKOUT
STRUCTURE CYCLE LENGTH INTO GREEN & RED
FLOPAT
OPTIMIZE OFFSET FOR INDIVIDUAL INTESECTIONS
IDEALO
FOR EACH TRIAL SYSTEM CYCLE LENGTH
SCALE LINKS BY IMPORTANCE OR SENSITIVITY
IMPORT
IDENTIFY SUBNETWORKS
SUBNET
RESRUCTURE SUBNETWORKS
NETWRK
OPTIMIZE SUBNETWORKS
SIGOS
OUTPUT SIGNAL PERFORMANCE & TIMING FOR GIVEN CYCLE LENGTH
FTABLE
OUTPUT SYSTEM PERFORMANCE FOR ALL TRIAL CYCLE LENGTHS
FINAL
OPTIONAL ECONOMIC ANALYSIS
ECNMC

INPT

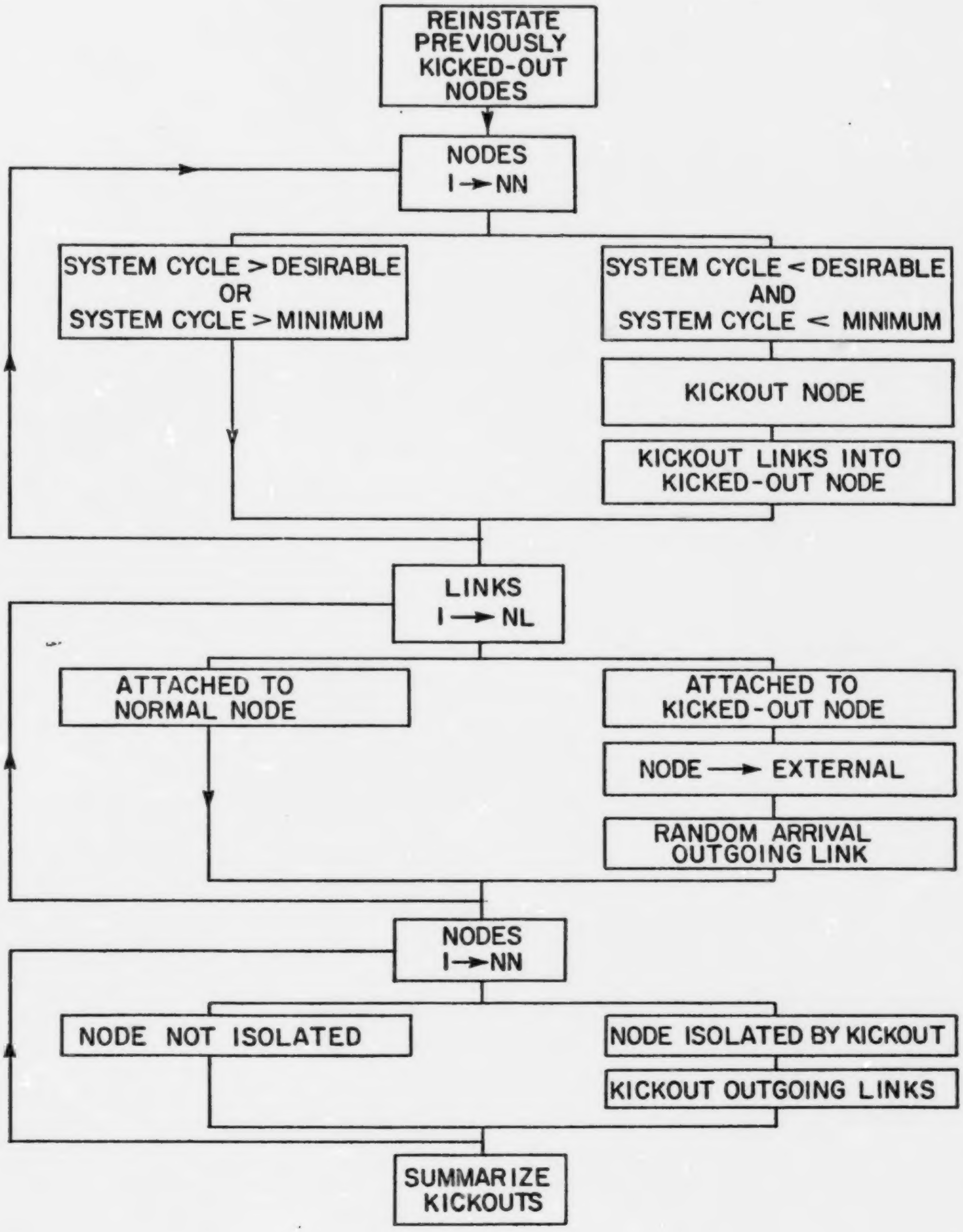

INITIALIZE PARAMETERS
READ
- CARD 1
- CARD 2
LINKS
NLC:1 →
NCARD 3
READ
- CARD 3
NODE NUMBER
SUBSEQUENT
FIRST
IDENTIFY NEW INTERSECTIONS
SET LINK & STAGE POINTERS
ASSIGN PROPERTIES TO PHASES
NODE TYPE
PRIORITY
NEUTRAL
READ
- CARD 4
IDENTIFY LINK SOURCES
ASSIGN PREVIOUS LINKS DATA IF PREVIOUS LINK HAD PRIORITY


READ NEXT CARD
CARD 99999
CARD 5
ASSIGN NEW VALUES
CHECK AGAINST DEFAULTS
CHECK FOR SOURCE NODES IN SOURCE LIST
PCU CONVERSION
SOURCE ARRAY TRANSFORMATION LINK POSITION ← LINK NUMBER
CARD 6 ?
NO
RETURN
NODES 1 → 6
READ CARD 6
STORE DATA
RETURN

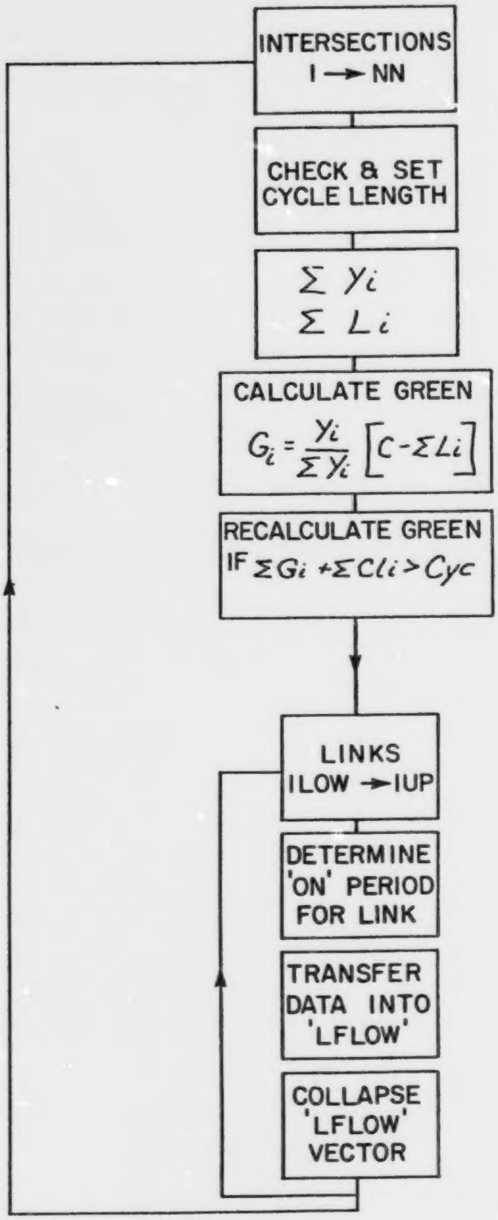
SPRITS


INTERSECTIONS
I — NN
LINK
ILOW — IUP
PCU
VOLUMES
TURN EQUIVALENTS
TURN EQUIVALENTS
IDENTIFY LINKS
PRIORITY GREEN
PHASE
I → 6
LINKS
ILOW — IUP
DETERMINE
CRITICAL V/S
FOR EACH
GREEN PERIOD
DETERMINE
CRITICAL LINKS
FOR PRIORITY
GREEN
MINIMUM
CYCLE LENGTH
PEDESTRIANS
MINIMUM GREEN
MINIMUM
GREEN
CYCLE LENGTH
WEBSTER
CAPACITIES
SATURATION
RATIOS
SELECTED
CYCLE LENGTHS

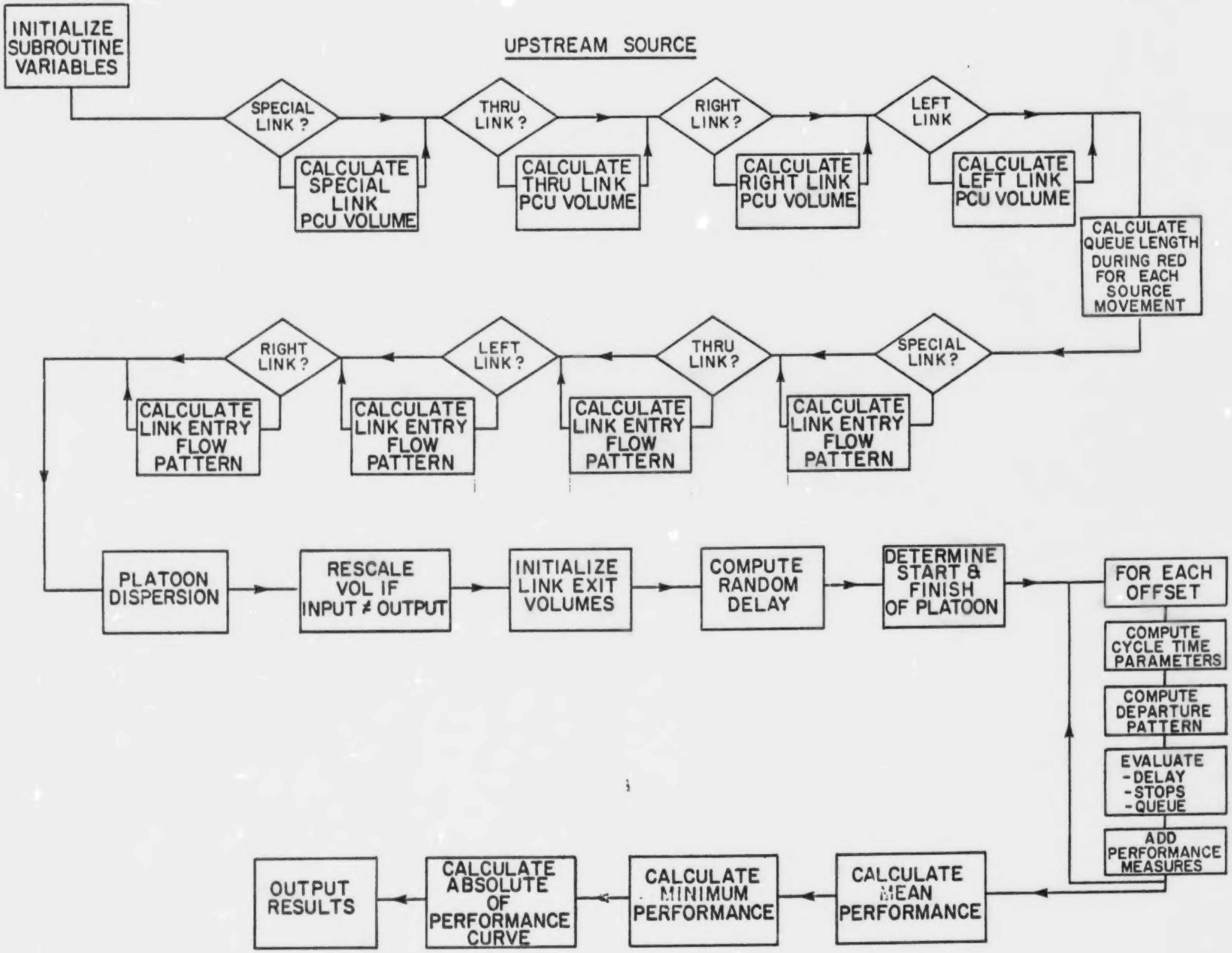
KICKOUT

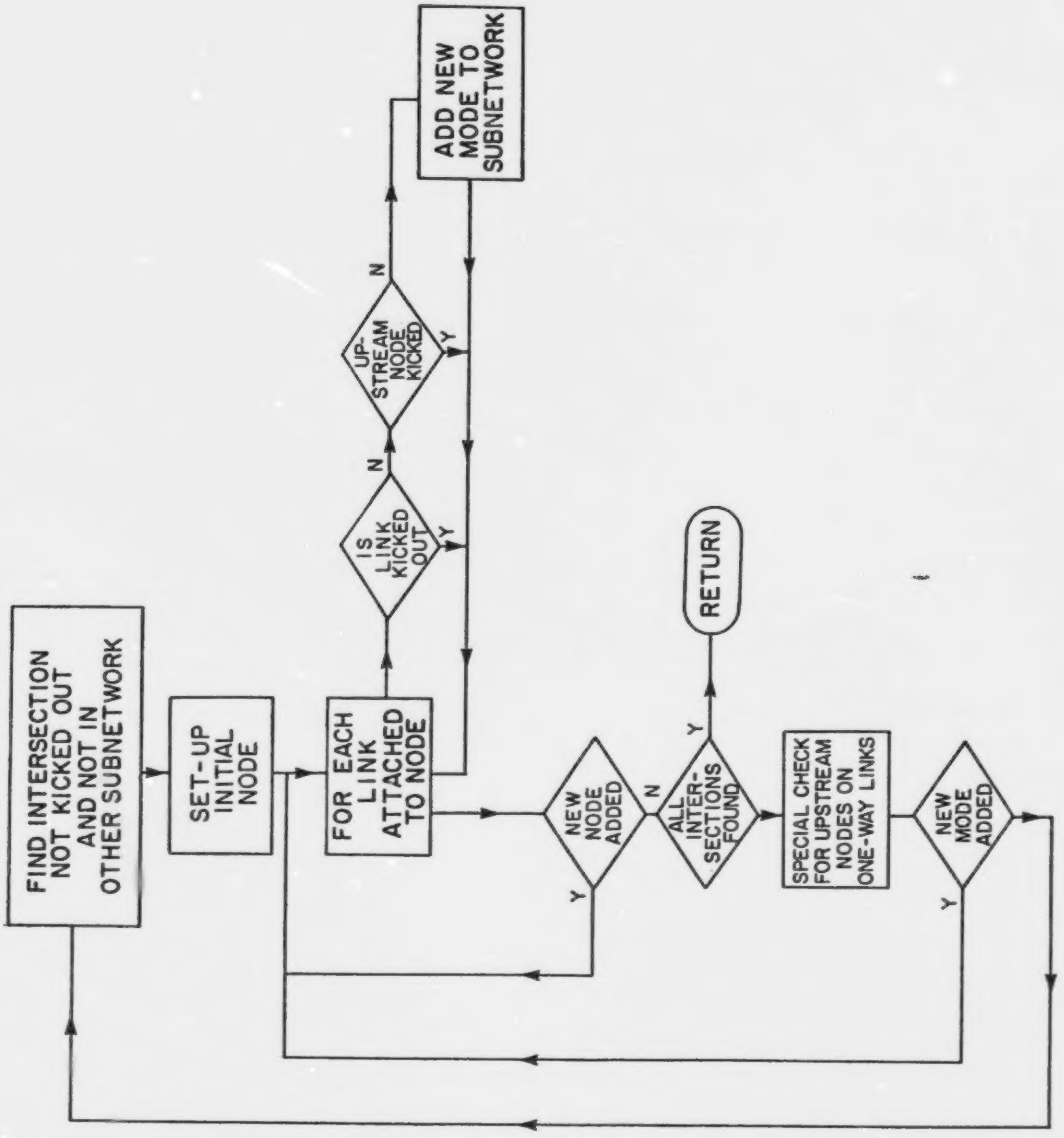

REINSTATE PREVIOUSLY KICKED-OUT NODES
NODES I → NN
SYSTEM CYCLE > DESIRABLE OR SYSTEM CYCLE > MINIMUM
SYSTEM CYCLE < DESIRABLE AND SYSTEM CYCLE < MINIMUM
KICKOUT NODE
KICKOUT LINKS INTO KICKED-OUT NODE
LINKS I → NL
ATTACHED TO NORMAL NODE
ATTACHED TO KICKED-OUT NODE
NODE → EXTERNAL
RANDOM ARRIVAL OUTGOING LINK
NODES I → NN
NODE NOT ISOLATED
NODE ISOLATED BY KICKOUT
KICKOUT OUTGOING LINKS
SUMMARIZE KICKOUTS

FLOPAT


INTERSECTIONS
I → NN
CHECK & SET CYCLE LENGTH
Σy_i
ΣL_i
CALCULATE GREEN
$G_i = \frac{y_i}{\Sigma y_i}\left[C - \Sigma L_i\right]$
RECALCULATE GREEN
IF $\Sigma G_i + \Sigma Cl_i > Cyc$
LINKS
ILOW → IUP
DETERMINE 'ON' PERIOD FOR LINK
TRANSFER DATA INTO 'LFLOW'
COLLAPSE 'LFLOW' VECTOR

IDEALO

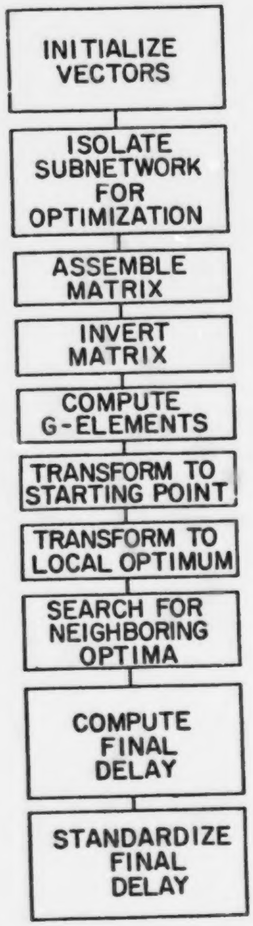

INITIALIZE SUBROUTINE VARIABLES
UPSTREAM SOURCE
SPECIAL LINK ?
CALCULATE SPECIAL LINK PCU VOLUME
THRU LINK ?
CALCULATE THRU LINK PCU VOLUME
RIGHT LINK ?
CALCULATE RIGHT LINK PCU VOLUME
LEFT LINK
CALCULATE LEFT LINK PCU VOLUME
CALCULATE QUEUE LENGTH DURING RED FOR EACH SOURCE MOVEMENT
SPECIAL LINK ?
CALCULATE LINK ENTRY FLOW PATTERN
THRU LINK ?
CALCULATE LINK ENTRY FLOW PATTERN
LEFT LINK ?
CALCULATE LINK ENTRY FLOW PATTERN
RIGHT LINK ?
CALCULATE LINK ENTRY FLOW PATTERN
PLATOON DISPERSION
RESCALE VOL IF INPUT ≠ OUTPUT
INITIALIZE LINK EXIT VOLUMES
COMPUTE RANDOM DELAY
DETERMINE START & FINISH OF PLATOON
FOR EACH OFFSET
COMPUTE CYCLE TIME PARAMETERS
COMPUTE DEPARTURE PATTERN
EVALUATE -DELAY -STOPS -QUEUE
ADD PERFORMANCE MEASURES
CALCULATE MEAN PERFORMANCE
CALCULATE MINIMUM PERFORMANCE
CALCULATE ABSOLUTE OF PERFORMANCE CURVE
OUTPUT RESULTS



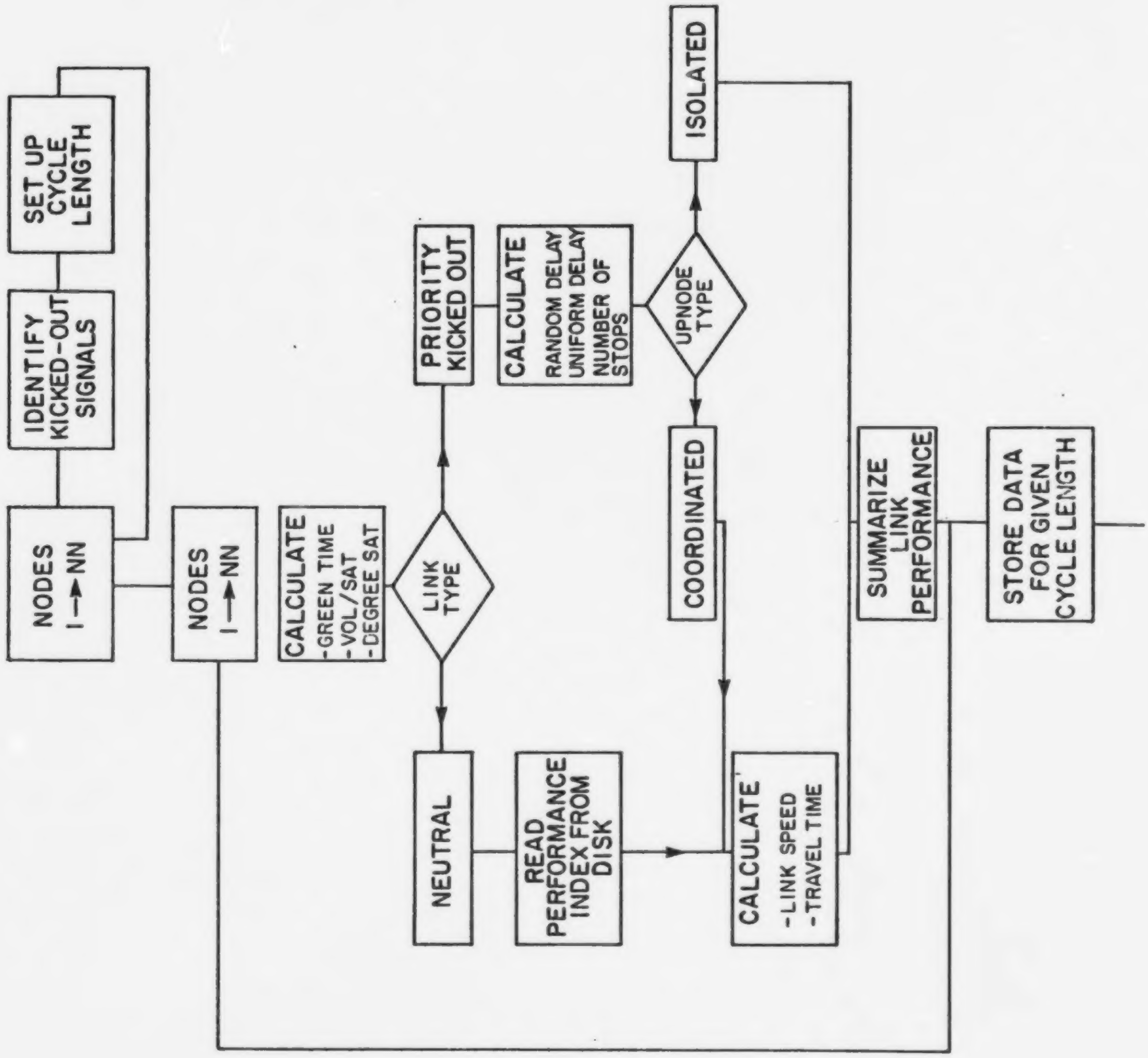
SUBNET

FIND INTERSECTION NOT KICKED OUT AND NOT IN OTHER SUBNETWORK
SET-UP INITIAL NODE
FOR EACH LINK ATTACHED TO NODE
IS LINK KICKED OUT
Y
N
UP-STREAM NODE KICKED
Y
N
ADD NEW MODE TO SUBNETWORK
NEW NODE ADDED
Y
N
ALL INTER-SECTIONS FOUND
Y
RETURN
SPECIAL CHECK FOR UPSTREAM NODES ON ONE-WAY LINKS
NEW MODE ADDED
Y

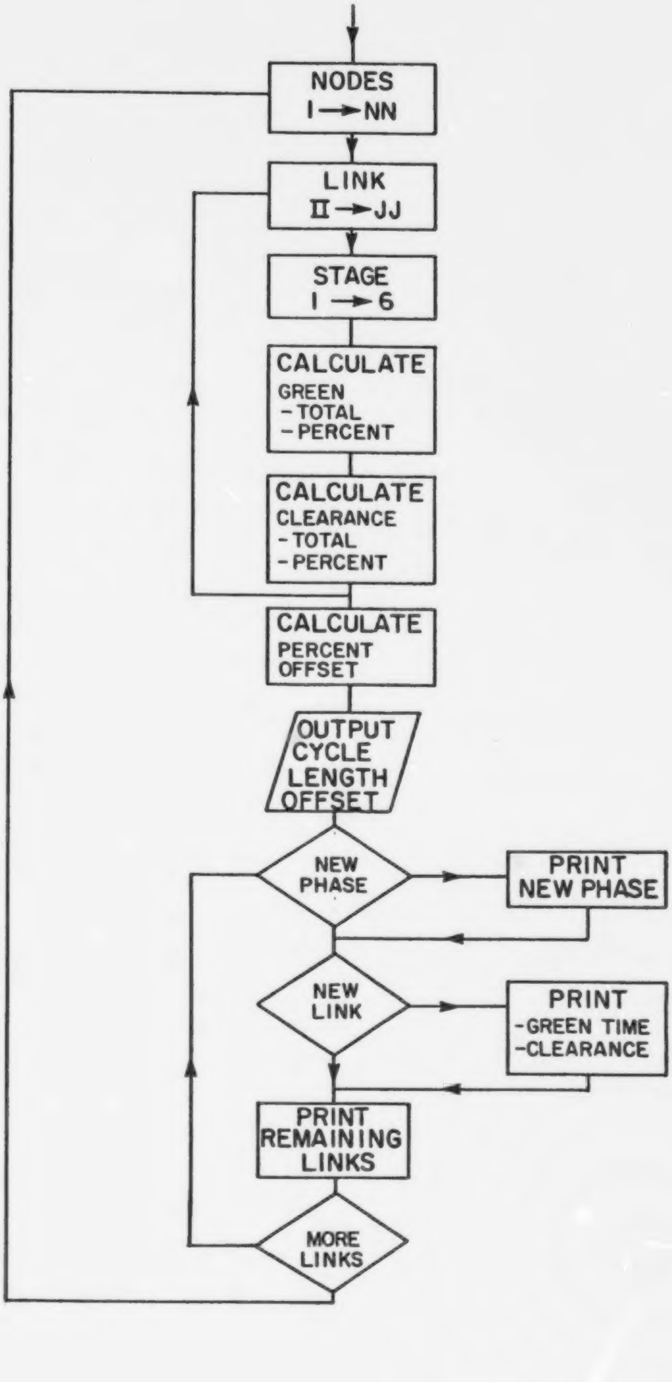
SIGOS


INITIALIZE VECTORS
ISOLATE SUBNETWORK FOR OPTIMIZATION
ASSEMBLE MATRIX
INVERT MATRIX
COMPUTE G-ELEMENTS
TRANSFORM TO STARTING POINT
TRANSFORM TO LOCAL OPTIMUM
SEARCH FOR NEIGHBORING OPTIMA
COMPUTE FINAL DELAY
STANDARDIZE FINAL DELAY

FTABLE


NODES
I → NN
IDENTIFY
KICKED-OUT
SIGNALS
SET UP
CYCLE
LENGTH
NODES
I → NN
CALCULATE
-GREEN TIME
-VOL/SAT
-DEGREE SAT
LINK
TYPE
PRIORITY
KICKED OUT
CALCULATE
RANDOM DELAY
UNIFORM DELAY
NUMBER OF
STOPS
UPNODE
TYPE
ISOLATED
COORDINATED
NEUTRAL
READ
PERFORMANCE
INDEX FROM
DISK
CALCULATE
-LINK SPEED
-TRAVEL TIME
SUMMARIZE
LINK
PERFORMANCE
STORE DATA
FOR GIVEN
CYCLE LENGTH

FTABLE


NODES
I → NN
LINK
II → JJ
STAGE
I → 6
CALCULATE
GREEN
- TOTAL
- PERCENT
CALCULATE
CLEARANCE
- TOTAL
- PERCENT
CALCULATE
PERCENT
OFFSET
OUTPUT
CYCLE
LENGTH
OFFSET
NEW
PHASE
PRINT
NEW PHASE
NEW
LINK
PRINT
-GREEN TIME
-CLEARANCE
PRINT
REMAINING
LINKS
MORE
LINKS

Appendix D
ADDENDUM FOR SSTOP USERS' GUIDE

INTRODUCTION

The SSTOP program has been enhanced to permit an economic comparison of various network improvement schemes. As a base for the option, vehicular fuel consumption due to signal produced delay and stops is now calculated. In addition, several link specific and network-wide adjustment factors have been made available to the user. These changes are documented below in terms of the additional input required and the resultant output. It must be emphasized that NO ADDITIONAL CODING EFFORT COMPARED TO THE INITIAL SSTOP VERSION IS REQUIRED if the new features are not desired.

INPUT

Card Type 3

Four link-specific adjustment factors have been added to each card type 3. Non-zero entries in these columns will override the network values for the corresponding parameters.

- Left turn tcu conversion factor - this value is multiplied by the left turn volume to obtain equivalent tcu volume. Columns 40-45, F5.0.
- Right turn tcu conversion factor - this value is multiplied by the right turn volume to obtain equivalent tcu volume. Columns 46-50, F5.0.
- Truck/bus tcu conversion factor - this value is multiplied by the truck/bus volume to obtain equivalent tcu volume. Columns 51-55, F5.0.
- Stop Penalty Factor - this value is multiplied by the number of vehicular stops and added to link delay to obtain a representative link performance index. Columns 56-60, F5.0.

Card Type 5

Two network wide adjustment parameters have been added to assess the sensitivity of the network to changes in link volumes and the minimum green policy.

- Volume Adjustment Factor - this value is multiplied by the coded link volume to obtain the modified volume. Columns 36-40, F5.0.
- Minimum Green Adjustment Factor - this value is multiplied by the coded link minimum green. Columns 41-45, F5.0.

Card Type 7

An optional card type 7 is included in the input data if an economic analysis of potential fuel consumption benefits is desired by the user. This card will immediately precede the 99999 card in the data deck. Included on this card is information concerning the base network performance values and the various economics parameters.

- Base Condition Delay (tcu-hrs/hr) - the total network delay calculated by SSTOP for the traffic network without the improvement under consideration. Columns 6-10, F5.0.

- Base Condition Stops (stops/hr) - the total network stops calculated by SSTOP for the base traffic network. Although these delays and stop values are not used in the economic analysis, their inclusion can help the user in identifying other potential benefits associated with a network improvement (e.g., a reduction in stops can reduce the number of rear-end collisions). Columns 11-15, F5.0.

- Base Condition Excess Fuel Consumption (L/hr) - the total network fuel consumed due to signal caused acceleration/deceleration and idling for the base condition. Columns 16-20, F5.0.

- Economic Analysis Type - two alternatives are available to the user: 1 = rate of return; 2 = net present worth. Column 25,I1.

- Equivalent Annual Factor - the SSTOP optimization is generally carried out for a representative hour of traffic conditions. The fuel consumption reduction for one hour is multiplied by the equivalent annual factor to produce a yearly estimate of fuel reduction under the proposed improvement. The value of this factor must be determined by the user based on his perception of the number of hours per year where similar benefits can be obtained. Columns 26-30, F5.0.

- Project Life (years) - the number of years in which fuel consumption benefits will be obtained. Columns 31-35, I5.

- Discount Rate (%) - this value is only required when the net present worth method is selected by the user. Columns 36-40, F5.0.

- Improvement Cost ($) - the present value cost of the network improvement. Columns 41-45, F5.0.

- Price of Fuel ($/L, $/gal) - the cost per unit fuel consumed is input either in terms of litres or gallons, depending on the type of units selected by the user in Card Type 2. Columns 46-50, F5.0.

OUTPUT

Input Data Network Parameters

This initial page, describing the input coded on card types 2 and 5, has been modified to identify the volume and minimum green adjustment factors, if utilized. A program run which employs both factors is shown in Figure D.1.

Link Performance

The inclusion of link fuel consumption data in this table has necessitated the deletion of link specific travel time output. This change is beneficial since fuel consumption information is of much greater value to the user than interval network travel time data. Figure D.2 displays the modified output for the Link Performance table.

Total System Performance Values

As with the Link Performance table, the network travel time column has been replaced by the network fuel consumption column. A sample output is shown in Figure D.3.

ECONOMIC ANALYSIS

The SSTOP output for the economic analysis option consists of a separate page following the 'TOTAL SYSTEM PERFORMANCE VALUES' table. The reductions in delay, stops and excess fuel consumption due to the network improvement are identified, as well as the annual benefits. Finally, the results of the economic analysis procedure are tabulated for either rate of return method (Figure D.4) or net present worth method (Figure D.5).

```
CHATHAM: KEIL STREET NETWORK      RICHMOND IMPROVEMENTS

   INPUT DATA-NETWORK PARAMETERS
   *****************************

   MINIMUM SYSTEM TRIAL CYCLE LENGTH=   60 SECONDS

   CYCLE LENGTH INCREMENT=              10 SECONDS

   MAXIMUM SYSTEM TRIAL CYCLE LENGTH=  120 SECONDS

   MAXIMUM KIKOUT SIGNAL CYCLE LENGTH= 150 SECONDS

   NUMBER OF LINKS IN NETWORK=          25

   NUMBER OF INTERSECTIONS=              5

   NETWORK STOP PENALTY=                 4 SEC/STOP

   NETWORK CLEARANCE INTERVAL=           5 SECONDS

   METRIC UNITS SPECIFIED

   OPTIMIZATION RUN.  FULL OUTPUT FOR EACH TRIAL CYCLE


   **OPTIONAL CARD 5 HAS BEEN INCLUDED
     THE FOLLOWING VALUES WILL BE USED

   LEFT TURN TCU=                       1.750

   RIGHT TURN TCU=                      1.250

   TRUCK AND BUS PCU=                   2.000

   LEFT TURN VEHICLES CLEARED IN AMBER=  100 PER HOUR

   PLATOON DISPERSION FACTOR=            0.25

   LINK VOLUME ADJUSTMENT FACTOR=       0.900

   MINIMUM GREEN ADJUSTMENT FACTOR=     1.200
```

FIGURE D.1

```
CHATHAM: KEIL STREET NETWORK     RICHMOND IMPROVEMENTS

   NETWORK CYCLE LENGTH=   60  SECONDS

   LINK PERFORMANCE
   ****************

INT"N  LINK     LINK       V/S   DEG.       DELAY        TCU  EXCESS   AVG
 NO.    NO.     NAME      RATIO   OF    (TCU-HRS/HR)   STOPS   FUEL  SPEED
                                 SAT.   ------------    PER  (L/HR)  (KPH)
                                        UNIFRM RANDM   HOUR

  1      11     THAMESS   0.129 0.376    1.32  0.06     316    15.2    -
         12     GRANDTW   0.196 0.624    3.60  0.26     600    29.5    -
         13     APTRDKN   0.043 0.125    0.30  0.00      51     2.5    -
        -14  ADVGRANDTE   0.164 1.143    1.12  0.36     165    10.3   11.4
         14     GRANDTE   0.159 0.327    1.59  0.04     352    12.4   35.8

  2      21     KEILGRS   0.139 0.736    3.36  0.51     425    25.0    -
        -22  ADVGRANDKW   0.320 1.067    3.03  1.10     441    29.4    8.0
         22     GRANDKW   0.103 0.207    0.55  0.01     102     3.3   34.2
        -23  ADVKEILGRN   0.183 1.410    1.89  1.67     272    13.3    7.2
         23     KEILGRN   0.266 0.772    3.29  0.65     446    13.1   22.7
         24     GRANDKE   0.162 0.810    5.00  0.85     556    33.0    -

  3     -31  ADVKEILRVS   0.143 1.350    1.72  1.35     136    12.3    5.7
         31     KEILRVS   0.469 0.379    7.57  1.55     865    33.7   19.9
         32     RIVERKW   0.213 0.913    5.67  2.11     434    33.6    -
         33     KEILRVW   0.231 0.639    7.36  0.23     748    34.0   31.7
        -34  ADVRIVERKE   0.216 1.473    2.77  1.64     221    13.3    -
         34     RIVERKE   0.182 0.463    1.07  0.10      94     5.0    -

  4      41     KEILRDS   0.215 0.759    2.85  0.59     529    13.4   35.7
         42     RICHDKW   0.115 0.575    1.50  0.20     339    11.5   22.4
        -44  ADVRICHDKE   0.340 1.020    1.56  0.63     354    17.2    -
         44     RICHDKE   0.207 0.365    0.62  0.05     191     3.0    -

  5      51     INTHVRS   0.100 0.353    0.75  0.05     139     6.6    -
         52     RICHDIW   0.276 0.534    2.23  0.15     630    27.1    -
         53     INTHVRN   0.071 0.251    0.49  0.02      91     4.3    -
         54     RICHDIE   0.321 0.621    1.34  0.23     691    16.7   34.4
```

FIGURE D.2

```
CHATHAM: KEIL STREET NETWORK      RICHMOND IMPROVEMENTS


     TOTAL SYSTEM PERFORMANCE VALUES
      *******************************

TRIAL    NO. OF       TOTAL  DELAY        TCU      PERF.        EXCESS        AVG.
CYCLE    KICKED      (TCU-HRS/HR)        STOPS     INDEX         FUEL        SYSTEM
LENGTH    OUT       ---------------       PER                CONSUMPTION     SPEED
(SEC)    SIGNALS    UNIFORM  RANDOM      HOUR                     (L/HR)     (KPH)

  60        3         64.2     14.5       9233      89.0         450.6        25.6

  70        3         66.9     14.6       8707      91.3         447.2        24.7

  80        3         67.8     13.8       8482      91.0         439.8        25.0

  90        1         69.0     13.6       8499      92.1         440.3        25.0

 100        0         54.4     13.5       7364      76.5         383.6        29.9

 110        0         58.8     12.9       7263      79.3         389.5        29.4

 120        0         62.8     11.6       7085      82.5         393.1        29.4


     THE OPTIMUM CYCLE IS  100 SECONDS
```

FIGURE D.3

```
CHATHAM: KEIL STREET NETWORK     RICHMOND IMPROVEMENTS


   ECONOMIC ANALYSIS
   *****************

                                        BASE       IMPROVED        REDUCTION
                                      CONDITION    CONDITION

   NETWORK DELAY (TCU-HRS/HR)            78.          68.             10.

   NETWORK STOPS (STOPS/HR)            8455.        7384.           1071.

   EXCESS FUEL CONSUMPTION (L/HR)       422.         384.             38.


   ANNUAL FUEL CONSUMPTION REDUCTION IS      37873. LITRES

   COST OF FUEL IS $ 0.40/LITRE

   ANNUAL BENEFIT DUE TO FUEL SAVING IS $    15149.

   PRESENT VALUE COST OF IMPROVEMENT IS $    75000.


   RATE OF RETURN METHOD:

            PROJECT LIFE IS 15 YEARS

            RATE OF RETURN =18.50%
```

FIGURE D.4

```
CHATHAM: KEIL STREET NETWORK     RICHMOND IMPROVEMENTS


   ECONOMIC ANALYSIS
   *****************

                                          BASE       IMPROVED      REDUCTION
                                        CONDITION    CONDITION

   NETWORK DELAY (TOL-HRS/HR)               73.          58.           10.

   NETWORK STOPS (STOPS/HR)               8455.        7384.         1071.

   EXCESS FUEL CONSUMPTION (L/HR)          422.         384.           38.


   ANNUAL FUEL CONSUMPTION REDUCTION IS       37873. LITRES

   COST OF FUEL IS $ 0.40/LITRE

   ANNUAL BENEFIT DUE TO FUEL SAVING IS $    15149.

   PRESENT VALUE COST OF IMPROVEMENT IS $    75000.


   NET PRESENT WORTH COMPARISON:

           DISCOUNT RATE IS 10.00%

           PROJECT LIFE IS  15 YEARS

           NET PRESENT WORTH BENEFITS = $   115227.


           BENEFIT : COST RATIO =  1.54 : 1
```

FIGURE D.5

Volume

2

Transport Canada　Transports Canada

TP 3764

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SSTOP PROGRAM ENHANCEMENTS

Volume II

PROGRAM FLOW CHART

Prepared for the
Transportation Development Centre
Transport Canada

JULY 1982

DeLCan DE LEUW CATHER, CANADA LTD.
CONSULTING ENGINEERS AND PLANNERS

09-1419

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17. Abstract

The SSTOP program was developed in Canada as a tool for optimizing traffic signal timings and offsets. The main objectives of the SSTOP enhancements were to provide fuel consumption estimates, sensitivity analysis improvements, and theoretical refinements in order to increase the overall performance of the program.

The addition of fuel consumption estimates and economic analysis to SSTOP provides the user with extra measures of effectiveness in order to evaluate data which are a direct result of the timing plans.

Sensitivity analysis enhancements provide the user with greater modelling capabilities by specifying volume conversion factors and stop penalties to individual links.

Theoretical enhancements to SSTOP have increased the accuracy of the Random Delay component, which in turn will provide a more realistic estimate of potential fuel consumption savings under various control scenarios.

The SSTOP program enhancements were tested on a network of five signalized intersections. A manual review of the SSTOP output concluded that the program produced results which compare favourably with manual results based on engineering judgement and experience.

18. Key Words
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Volume III: Program Source Listing

16. Agent de projet — CDT
Sylvie Corbeil

17. Résumé

Le programme SSTOP est une méthode développée au Canada pour accroître la capacité du réseau routier et le débit de la circulation par une coordination automatique des feux de circulation. Le perfectionnement du programme initial visait à le rendre capable de faire des estimations de la consommation de carburant, à développer ses capacités d'analyse de sensibilité et à dégager les perfectionnements conceptuels susceptibles d'optimiser le rendement global de SSTOP.

Cette nouvelle capacité de faire des estimations de la consommation accompagnées d'une analyse économique permet d'apprécier l'efficacité du mode de contrôle retenu, à même les données découlant directement de l'application de celui-ci.

Le développement du programme d'analyse de sensibilité permet une modélisation plus détaillée des paramètres de coordination en variant les temps d'attente et les facteurs de conversion des débits selon la liaison considérée.

Quant aux améliorations conceptuelles, elles se matérialisent par une plus grande précision de la composante "délais aléatoires" du programme ce qui, à son tour, permet une meilleure estimation des économies d'énergie réalisables par chacun des divers scénarios envisagés.

Le programme perfectionné a été testé sur un réseau de cinq carrefours équipés de feux de circulation. Une analyse manuelle des résultats a permis de conclure que ce programme se compare favorablement à la méthode fondée sur des enquêtes in situ dans lesquelles l'expérience et l'appréciation entrent pour une large part.

18. Mots-clés
Énergie, carburant, économie d'énergie, programme informatique, feux de circulation, coordination automatique, circulation urbaine.

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INTRODUCTION

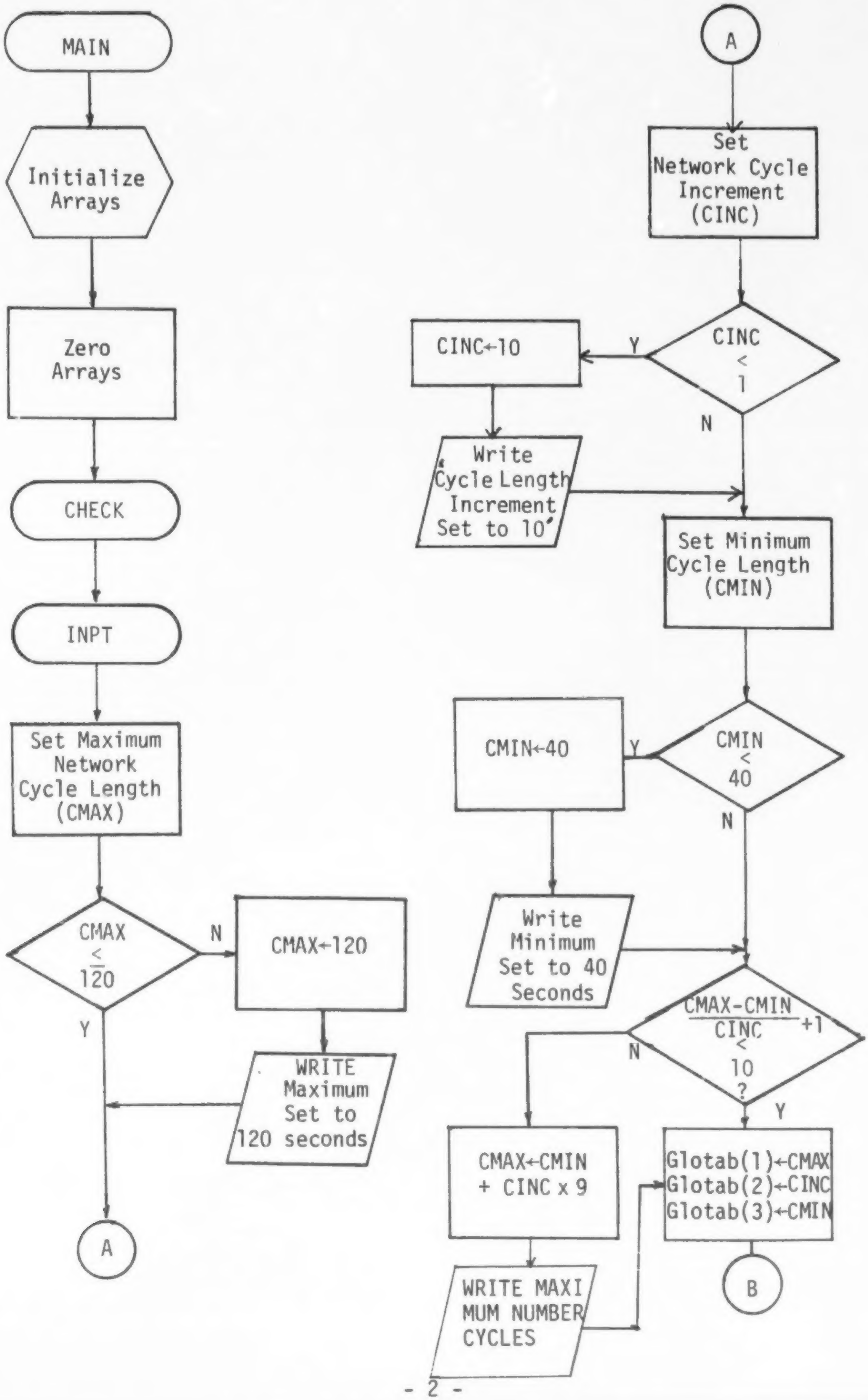
Contained in this Volume II of the SSTOP Program Enhancement Report is the Detailed Flow Chart of the program logic of the enhanced SSTOP Program.

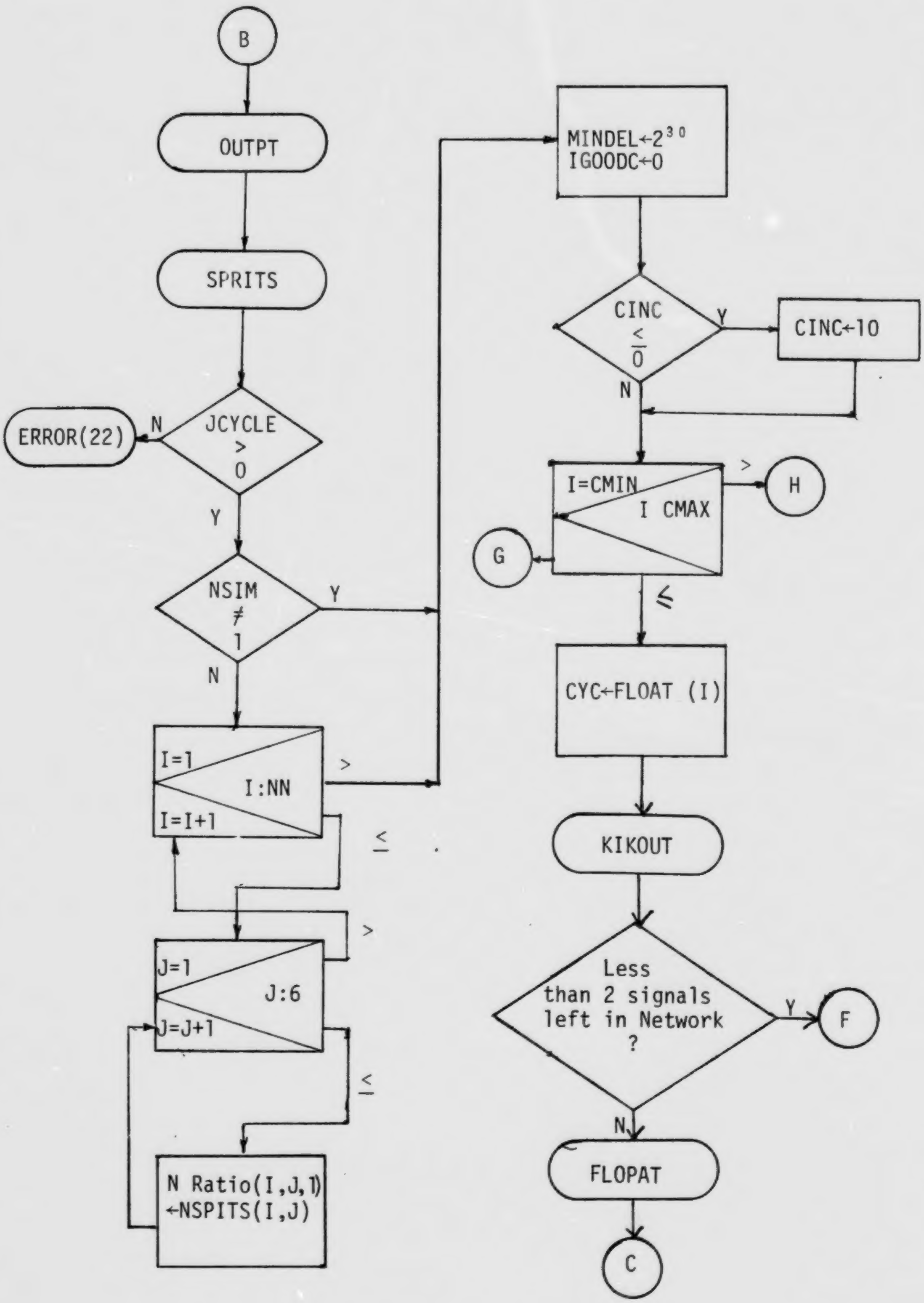
The Detailed Flow Chart consists of the following major sections:

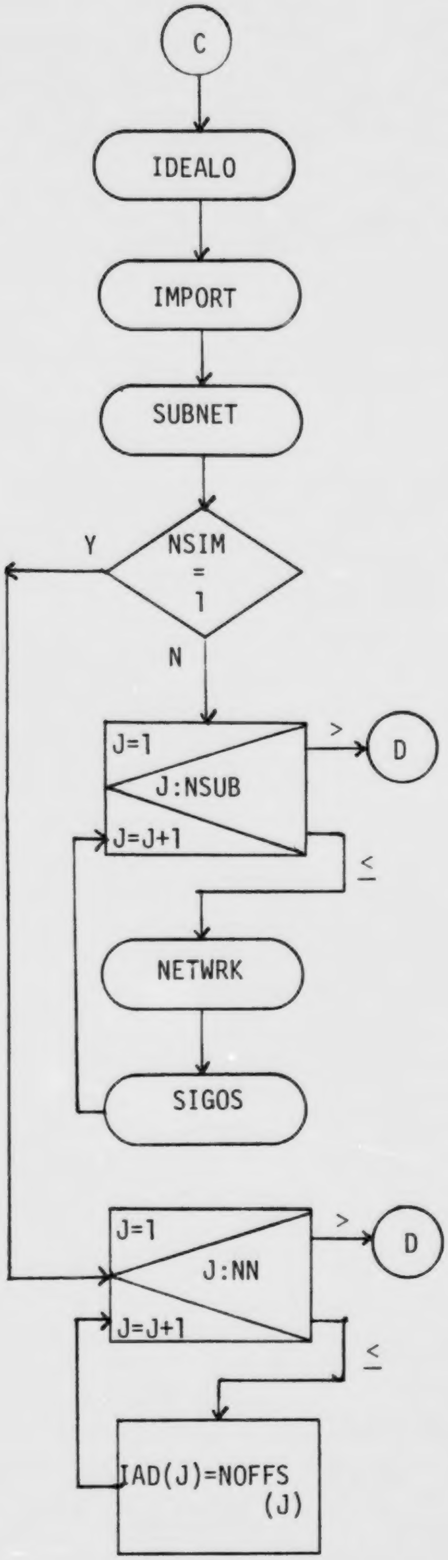
1. Main Program

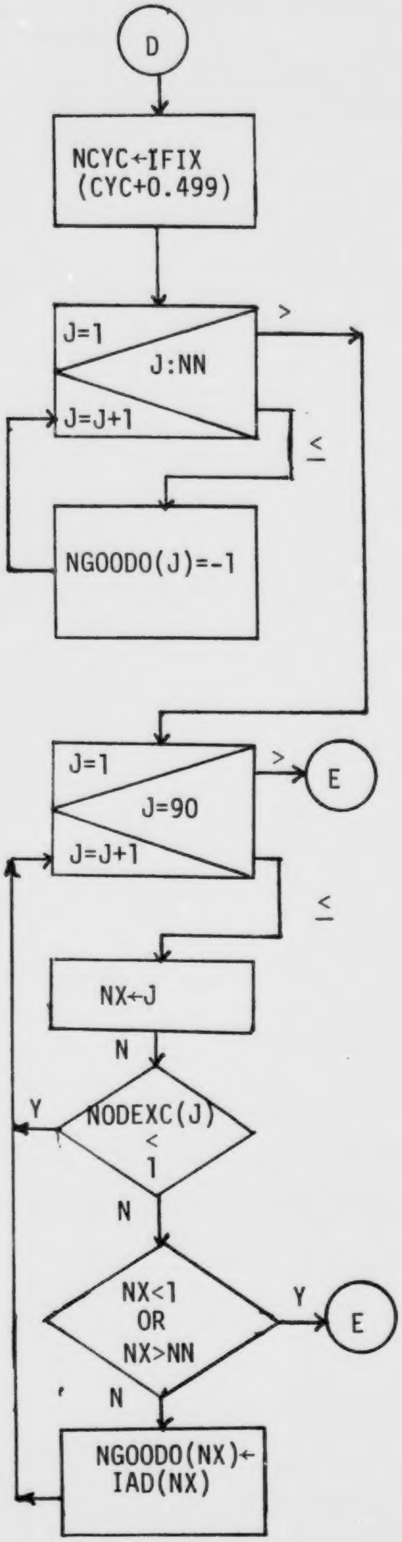
2. Subroutines
    - CHECK
    - INPT
    - OUTPT
    - SPRITS
    - KICKOUT
    - FLOPAT
    - IDEALO
    - IMPORT
    - SUBNET
    - NETWRK
    - SIGOS
    - FTABLE
    - FINAL
    - ECNMC

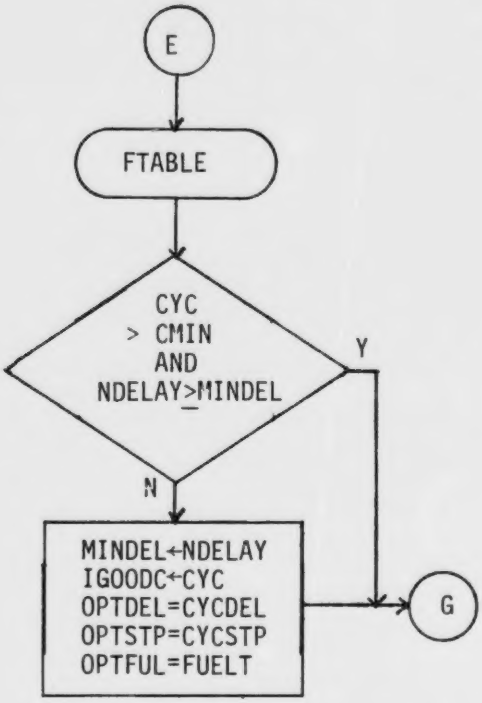
SSTOP FLOWCHART

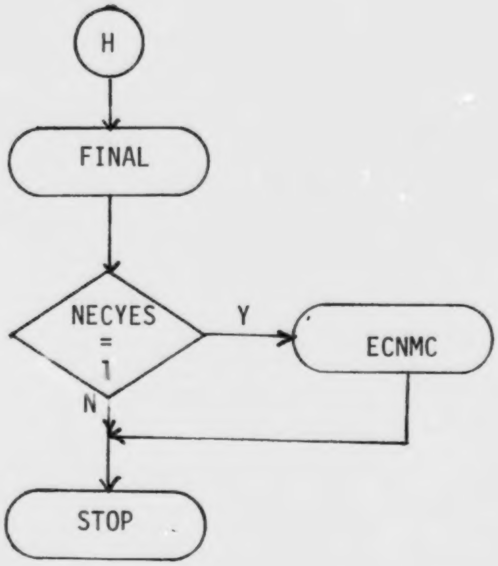

MAIN
Initialize Arrays
Zero Arrays
CHECK
INPT
Set Maximum Network Cycle Length (CMAX)
CMAX ≤ 120
N
Y
CMAX←120
WRITE Maximum Set to 120 seconds
A
A
Set Network Cycle Increment (CINC)
CINC < 1
Y
N
CINC←10
Write 'Cycle Length Increment Set to 10'
Set Minimum Cycle Length (CMIN)
CMIN < 40
Y
N
CMIN←40
Write Minimum Set to 40 Seconds
(CMAX-CMIN)/CINC +1 ≤ 10 ?
N
Y
CMAX←CMIN + CINC x 9
WRITE MAXIMUM NUMBER CYCLES
Glotab(1)←CMAX
Glotab(2)←CINC
Glotab(3)←CMIN
B

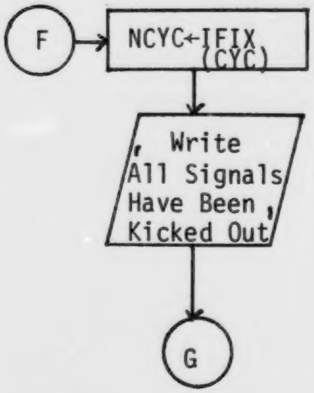

B
OUTPT
SPRITS
JCYCLE > 0
N
ERROR(22)
Y
NSIM ≠ 1
Y
N
I=1
I:NN
I=I+1
>
≤
J=1
J:6
J=J+1
>
≤
N Ratio(I,J,1) ←NSPITS(I,J)
MINDEL←2^30
IGOODC←0
CINC ≤ 0
Y
CINC←10
N
I=CMIN
I CMAX
>
H
G
≤
CYC←FLOAT (I)
KIKOUT
Less than 2 signals left in Network ?
Y
F
N
FLOPAT
C


C
IDEALO
IMPORT
SUBNET
NSIM = 1
Y
N
J=1
J:NSUB
J=J+1
>
D
≤
NETWRK
SIGOS
J=1
J:NN
J=J+1
>
D
≤
IAD(J)=NOFFS (J)

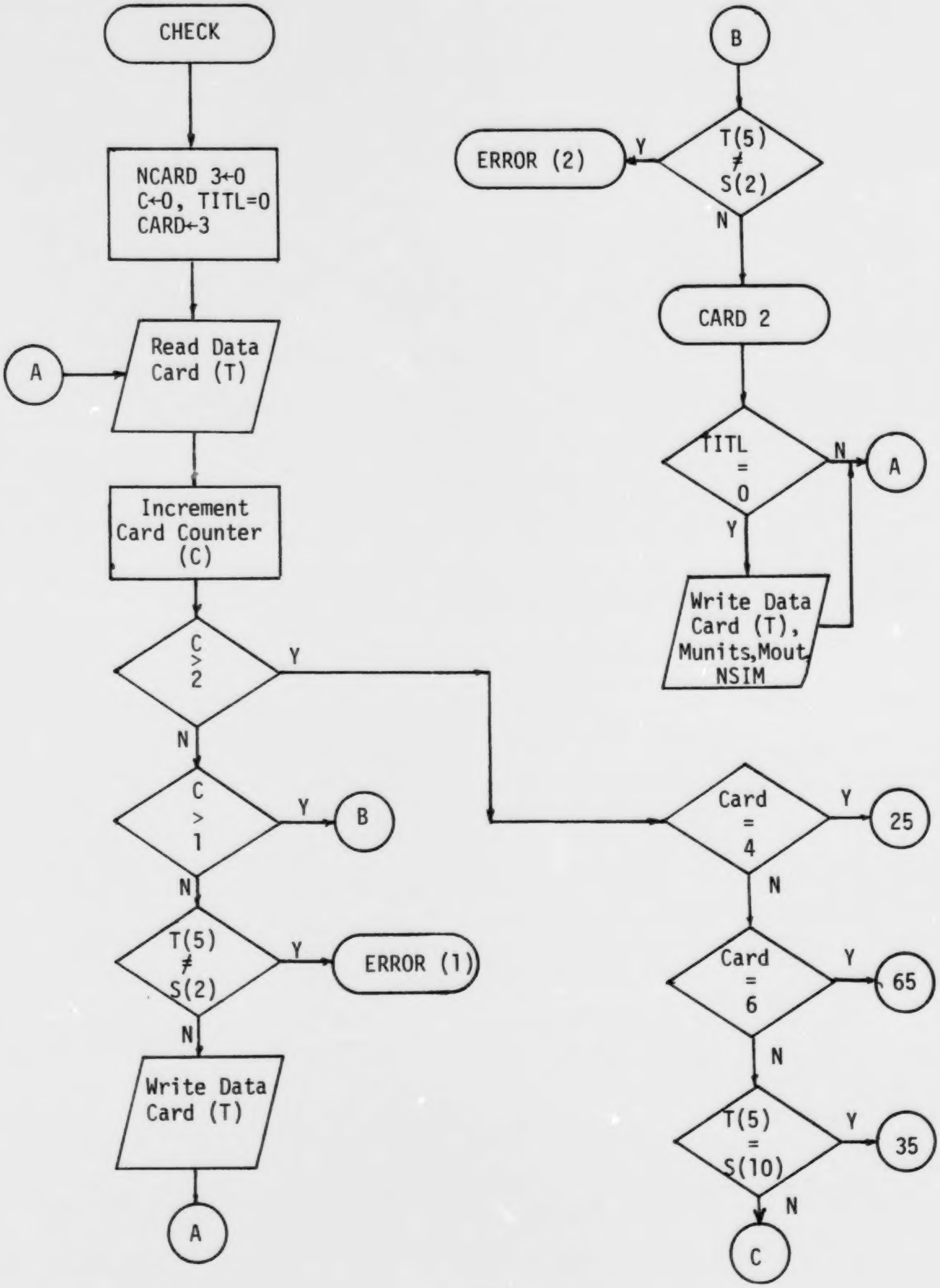

D
NCYC←IFIX (CYC+0.499)
J=1
J:NN
J=J+1
>
≤
NGOODO(J)=-1
J=1
J=90
J=J+1
>
E
≤
NX←J
N
NODEXC(J) < 1
Y
N
NX<1 OR NX>NN
Y
E
N
NGOODO(NX)← IAD(NX)


E
FTABLE
CYC > CMIN AND NDELAY≥MINDEL
Y
N
MINDEL←NDELAY
IGOODC←CYC
OPTDEL=CYCDEL
OPTSTP=CYCSTP
OPTFUL=FUELT
G

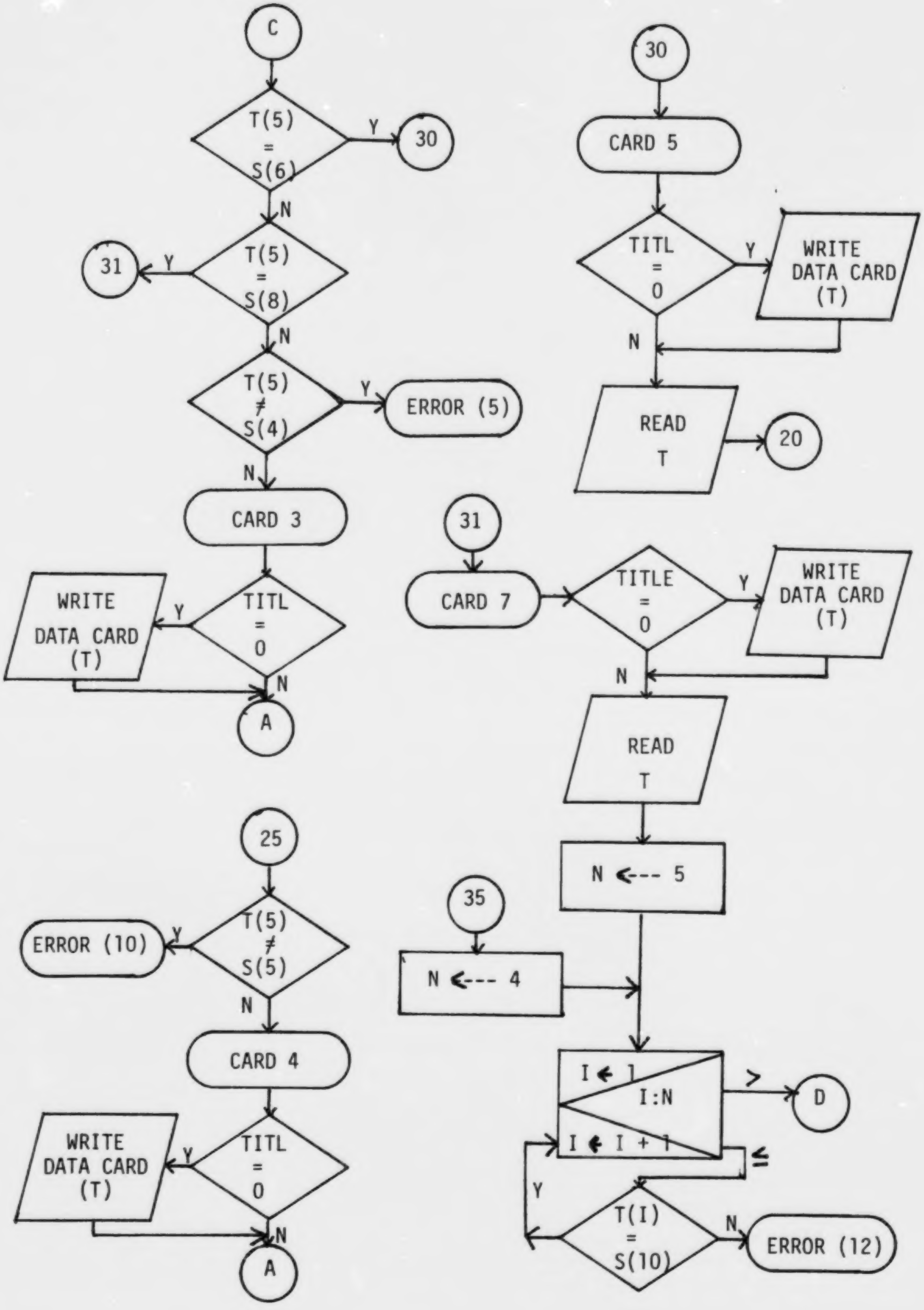

H
FINAL
NECYES = 1
Y
N
ECNMC
STOP


F
NCYC←IFIX (CYC)
Write All Signals Have Been Kicked Out
G

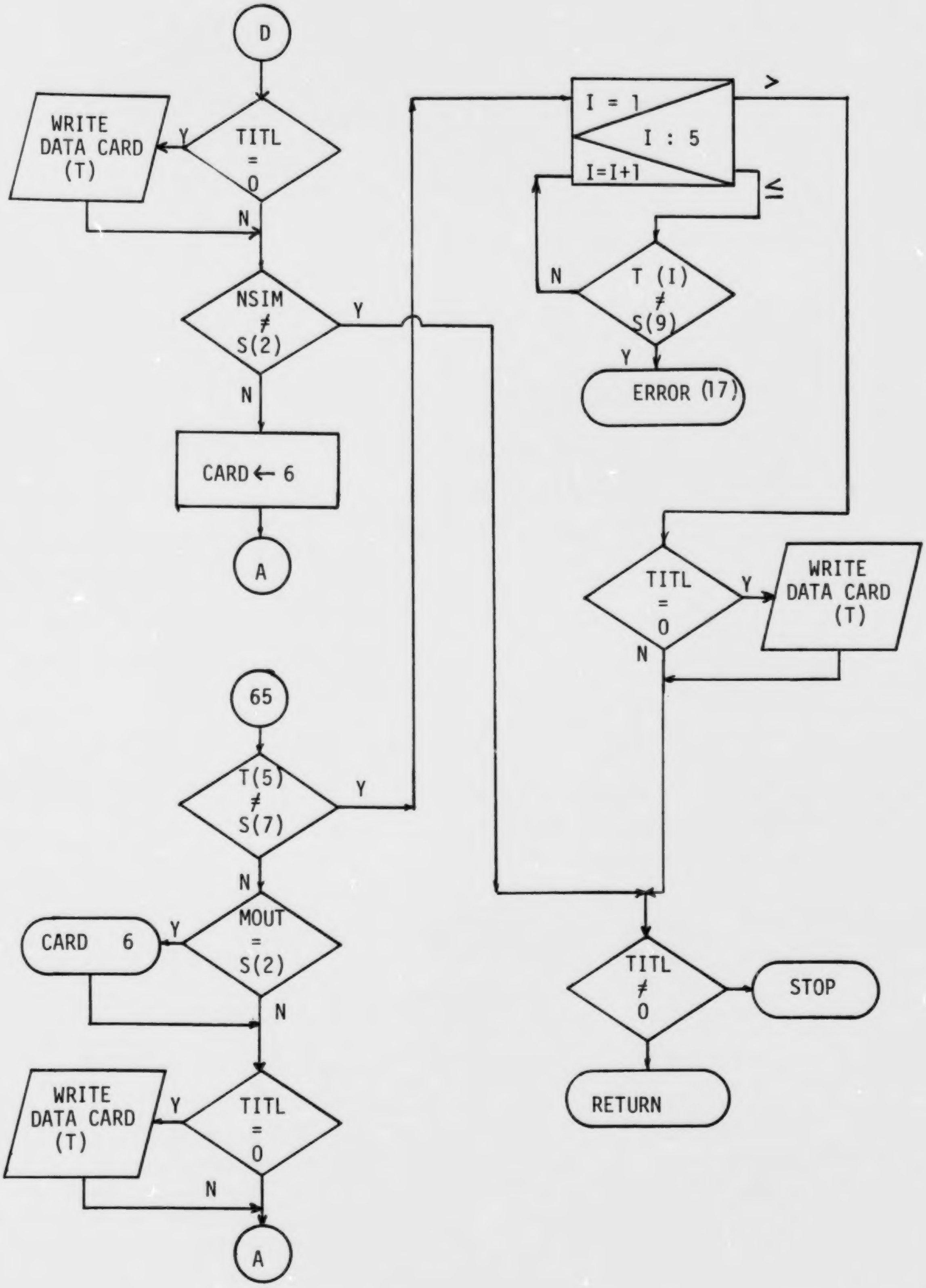
CHECK


CHECK
NCARD 3←0
C←0, TITL=0
CARD←3
A
Read Data Card (T)
Increment Card Counter (C)
C > 2
Y
N
C > 1
Y
B
N
T(5) ≠ S(2)
Y
ERROR (1)
N
Write Data Card (T)
A
B
T(5) ≠ S(2)
Y
ERROR (2)
N
CARD 2
TITL = 0
N
A
Y
Write Data Card (T), Munits,Mout NSIM
Card = 4
Y
25
N
Card = 6
Y
65
N
T(5) = S(10)
Y
35
N
C

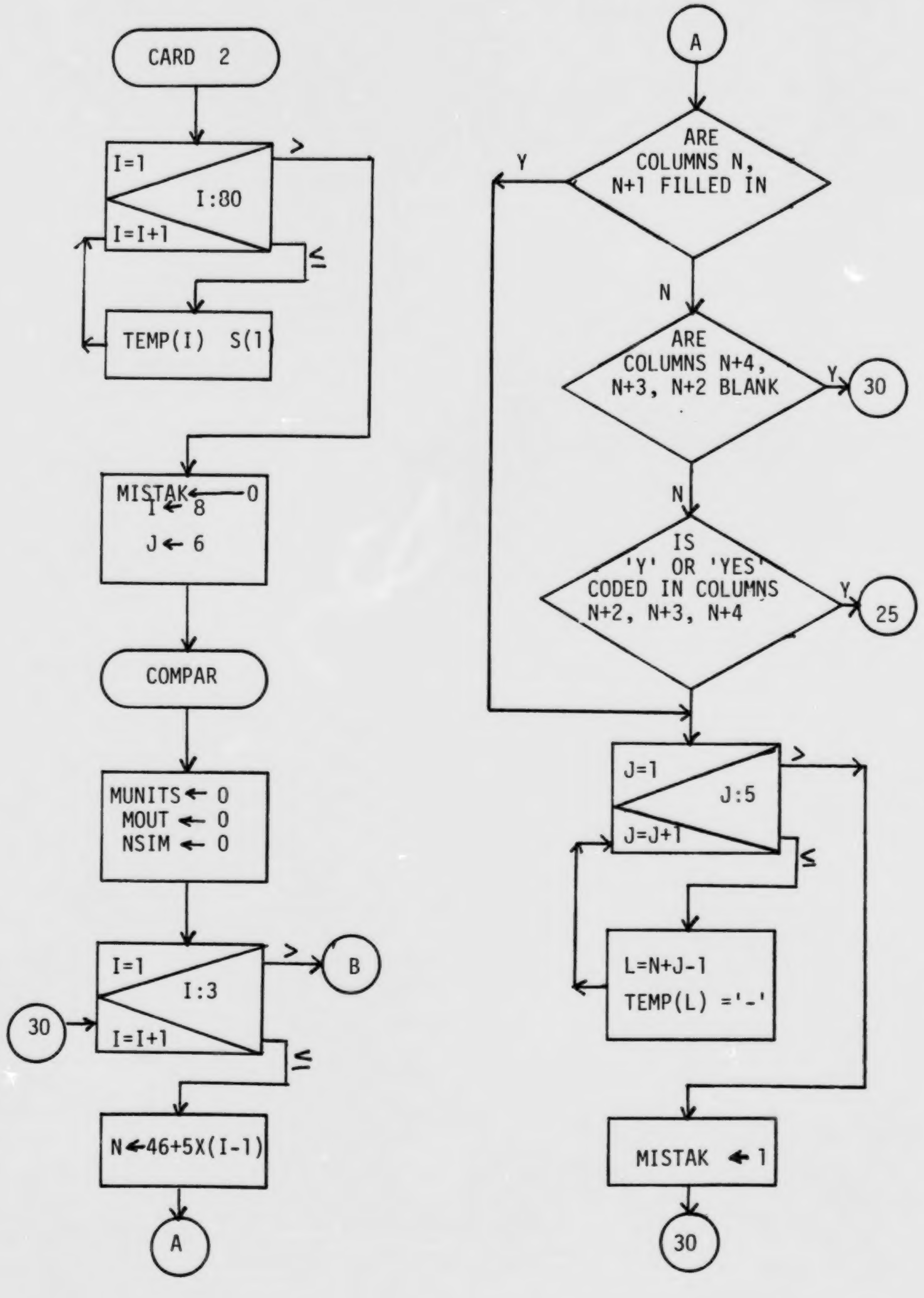
CHECK


C
T(5) = S(6)
Y
30
N
T(5) = S(8)
Y
31
N
T(5) ≠ S(4)
Y
ERROR (5)
N
CARD 3
TITL = 0
Y
WRITE DATA CARD (T)
N
A
30
CARD 5
TITL = 0
Y
WRITE DATA CARD (T)
N
READ T
20
31
CARD 7
TITLE = 0
Y
WRITE DATA CARD (T)
N
READ T
N ← 5
25
T(5) ≠ S(5)
Y
ERROR (10)
N
CARD 4
TITL = 0
Y
WRITE DATA CARD (T)
N
A
35
N ← 4
I ← 1
I:N
I ← I + 1
>
D
≤
Y
T(I) = S(10)
N
ERROR (12)

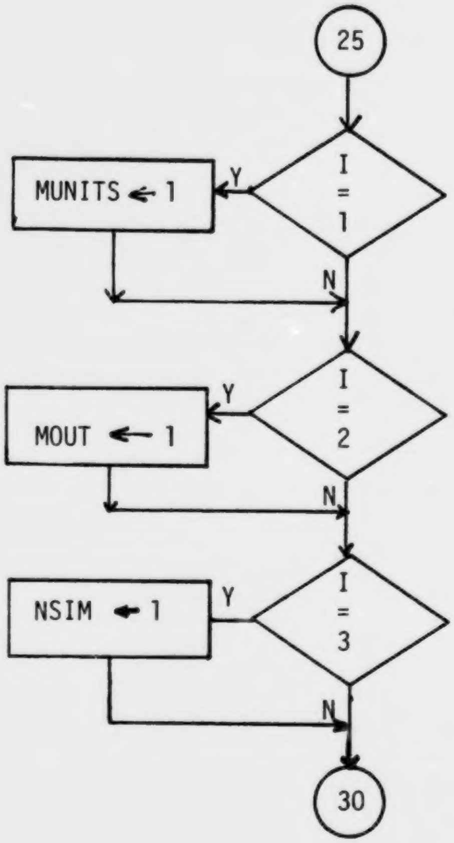
CHECK

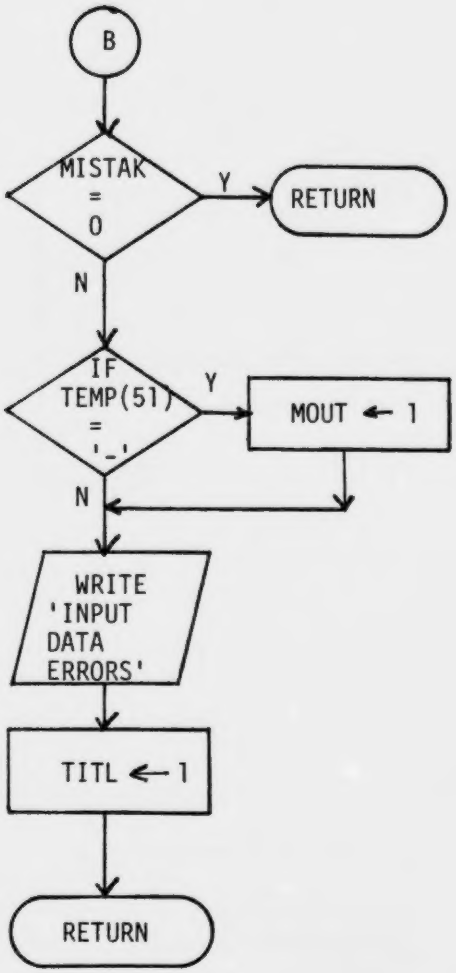

D
WRITE
DATA CARD
(T)
Y
TITL
=
0
N
NSIM
≠
S(2)
Y
N
CARD ← 6
A
I = 1
I : 5
I=I+1
>
≤
T (I)
≠
S(9)
N
Y
ERROR (17)
TITL
=
0
Y
WRITE
DATA CARD
(T)
N
65
T(5)
≠
S(7)
Y
N
MOUT
=
S(2)
Y
CARD 6
N
WRITE
DATA CARD
(T)
Y
TITL
=
0
N
A
TITL
≠
0
STOP
RETURN

CARD 2 SUBROUTINE

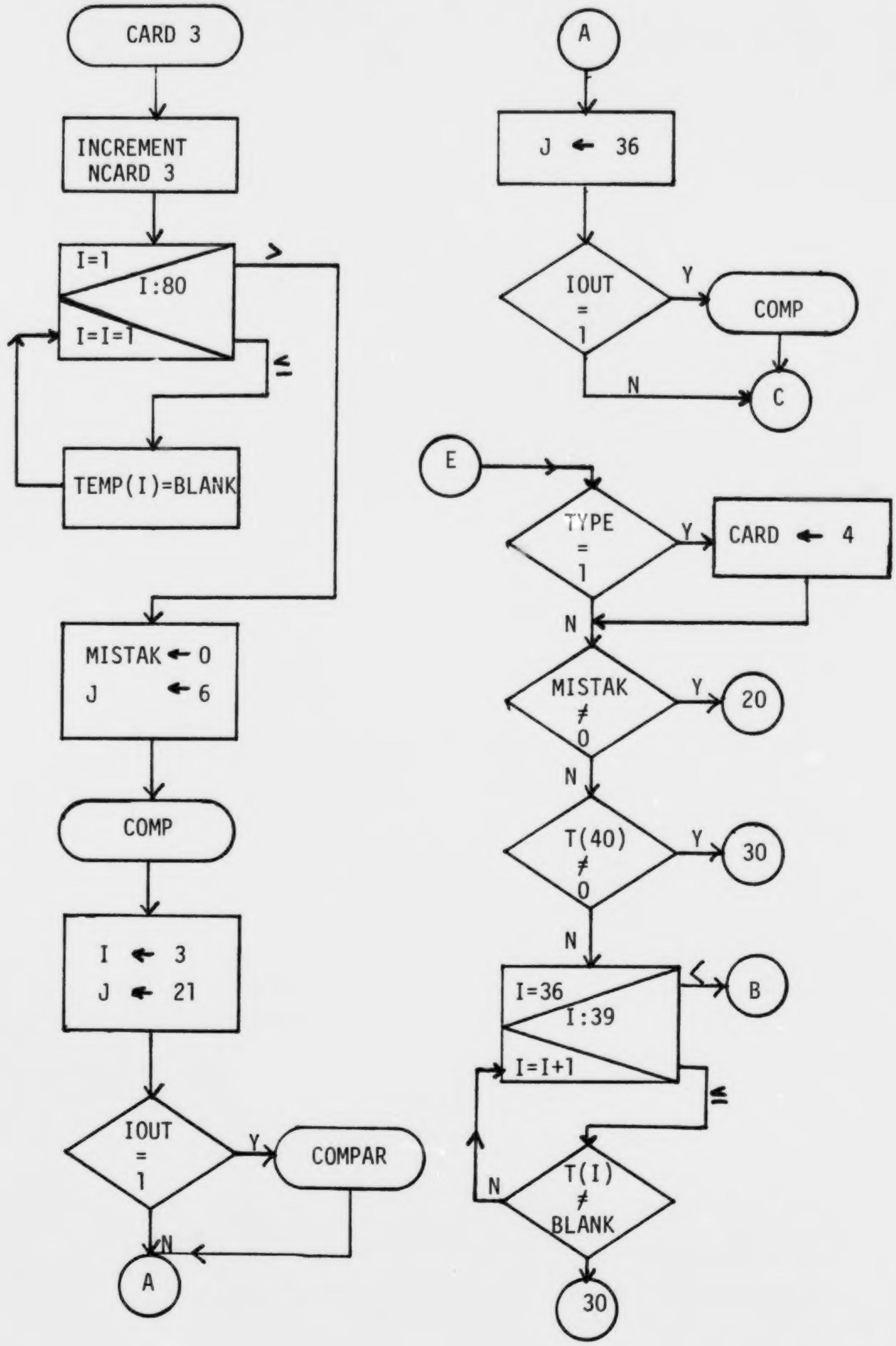

CARD 2
I=1
I:80
I=I+1
>
≤
TEMP(I) S(1)
MISTAK ← 0
I ← 8
J ← 6
COMPAR
MUNITS ← 0
MOUT ← 0
NSIM ← 0
I=1
I:3
I=I+1
>
≤
B
30
N ← 46+5X(I-1)
A
A
ARE COLUMNS N, N+1 FILLED IN
Y
N
ARE COLUMNS N+4, N+3, N+2 BLANK
Y
30
N
IS 'Y' OR 'YES' CODED IN COLUMNS N+2, N+3, N+4
Y
25
J=1
J:5
J=J+1
>
≤
L=N+J-1
TEMP(L) ='-'
MISTAK ← 1
30

CARD 2

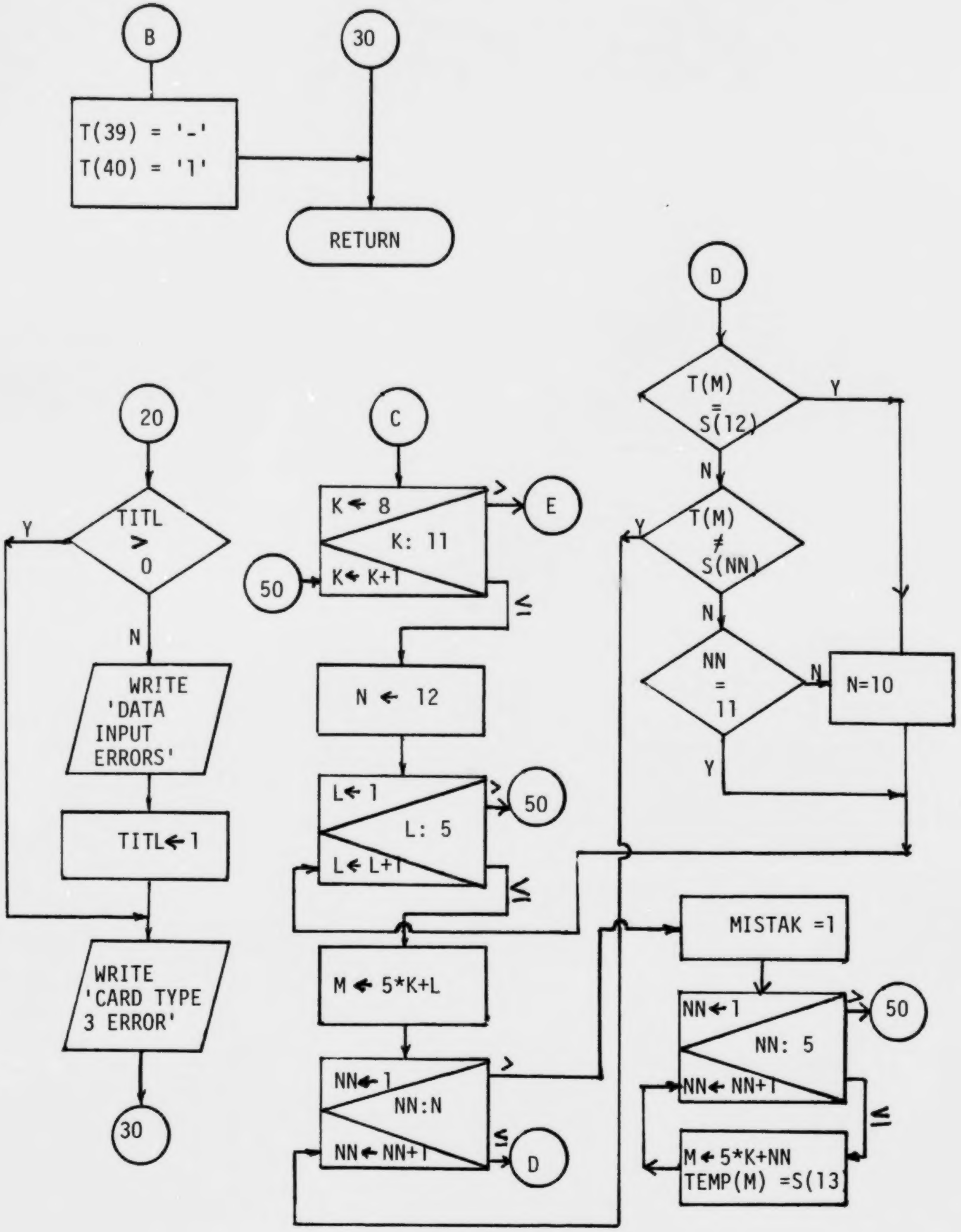

25
I = 1
Y
MUNITS ← 1
N
I = 2
Y
MOUT ← 1
N
I = 3
Y
NSIM ← 1
N
30


B
MISTAK = 0
Y
RETURN
N
IF TEMP(51) = '_'
Y
MOUT ← 1
N
WRITE 'INPUT DATA ERRORS'
TITL ← 1
RETURN

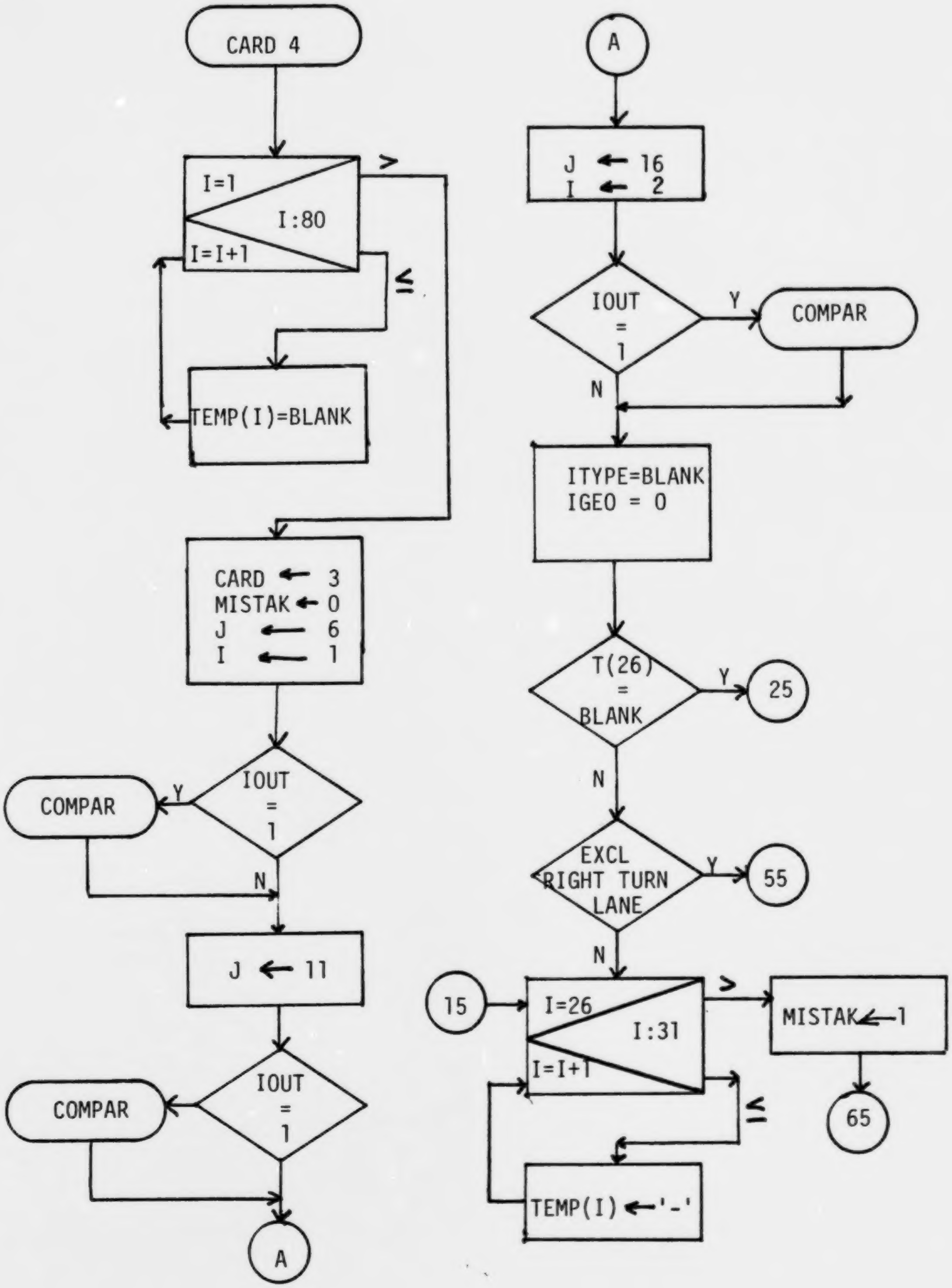
CARD 3 SUBROUTINE


CARD 3
INCREMENT NCARD 3
I=1
I:80
I=I=1
>
≤
TEMP(I)=BLANK
MISTAK ← 0
J ← 6
COMP
I ← 3
J ← 21
IOUT = 1
Y
COMPAR
N
A
A
J ← 36
IOUT = 1
Y
COMP
N
C
E
TYPE = 1
Y
CARD ← 4
N
MISTAK ≠ 0
Y
20
N
T(40) ≠ 0
Y
30
N
I=36
I:39
I=I+1
<
B
≤
N
T(I) ≠ BLANK
30

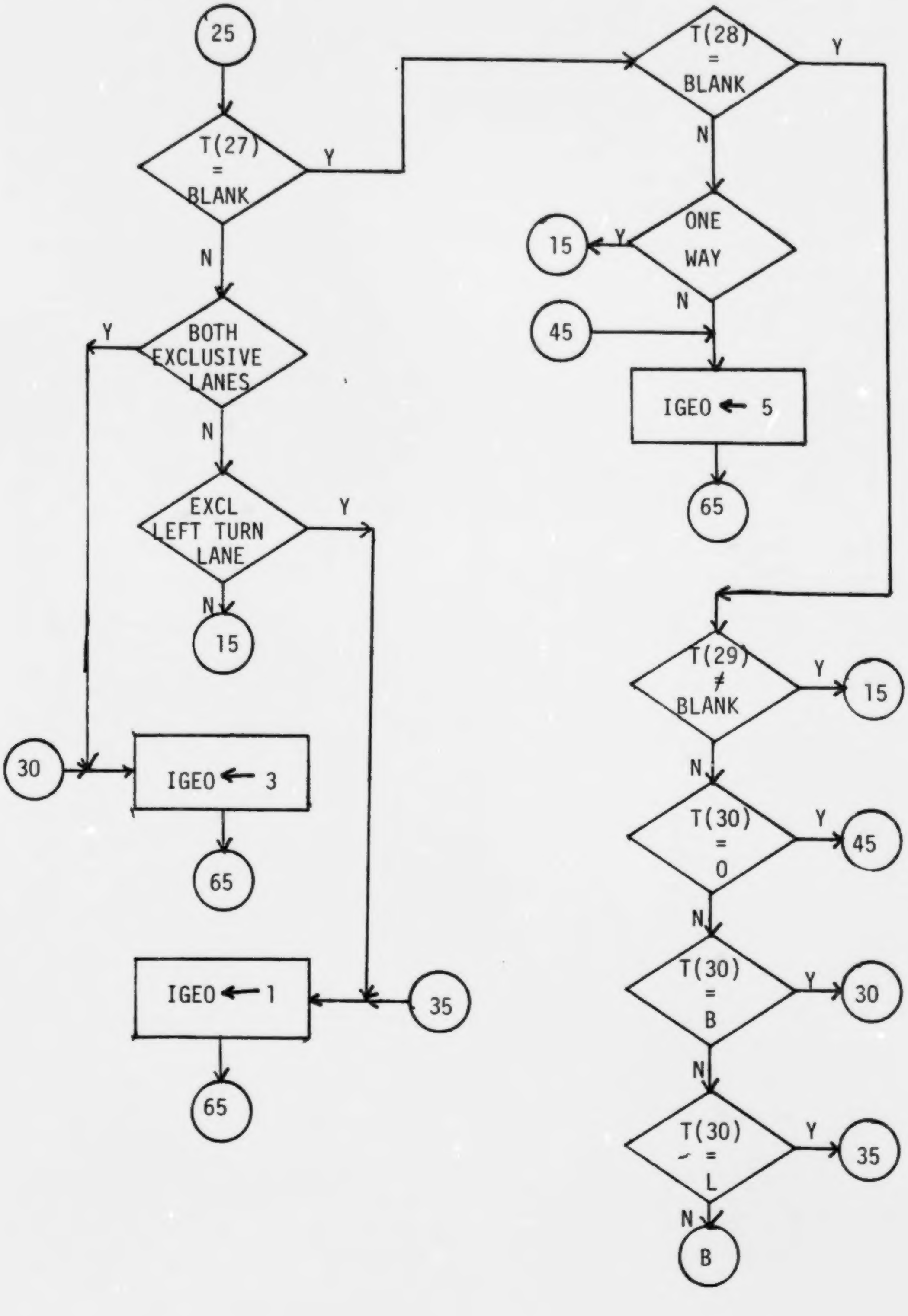
CARD 3


B
30
T(39) = '-'
T(40) = '1'
RETURN
D
T(M) = S(12)
Y
N
T(M) ≠ S(NN)
Y
N
NN = 11
N
Y
N=10
20
TITL > 0
Y
N
WRITE 'DATA INPUT ERRORS'
TITL← 1
WRITE 'CARD TYPE 3 ERROR'
30
C
K ← 8
K: 11
K ← K+1
>
E
50
≤
N ← 12
L← 1
L: 5
L ← L+1
>
50
≤
M ← 5*K+L
NN← 1
NN:N
NN ← NN+1
>
≤
D
MISTAK =1
NN← 1
NN: 5
NN← NN+1
>
50
≤
M ← 5*K+NN
TEMP(M) =S(13

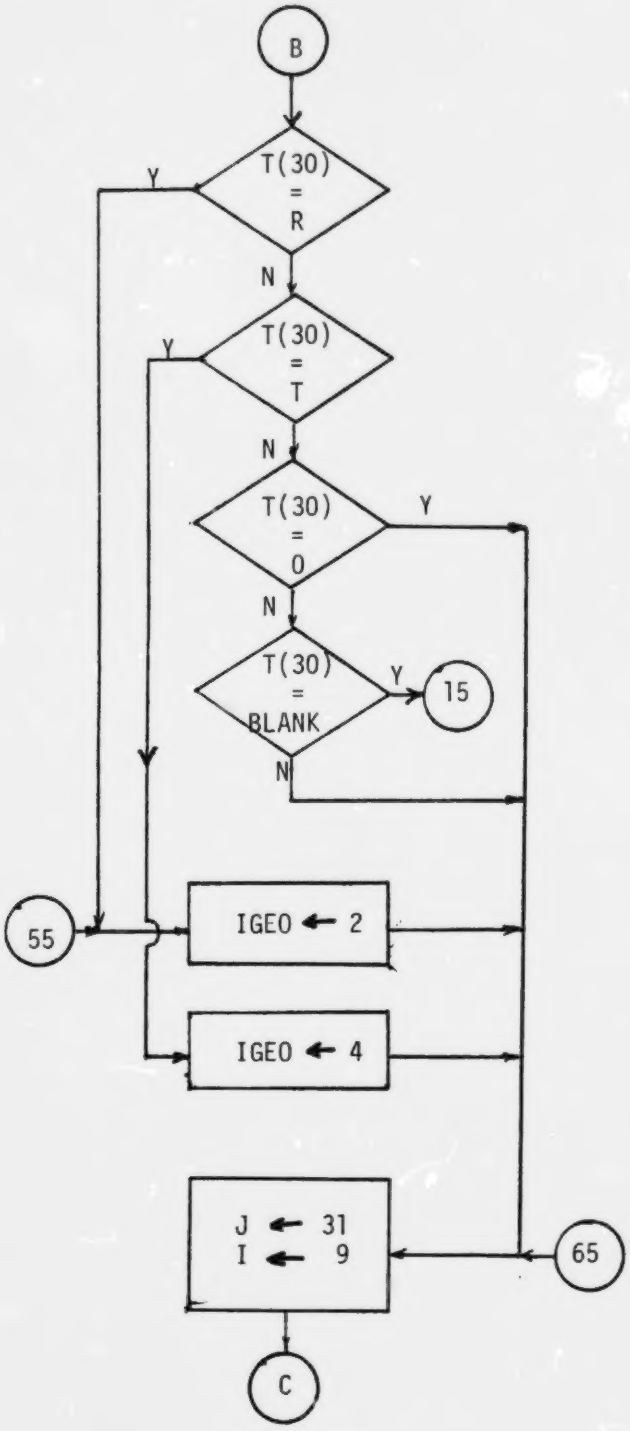
CARD 4 SUBROUTINE

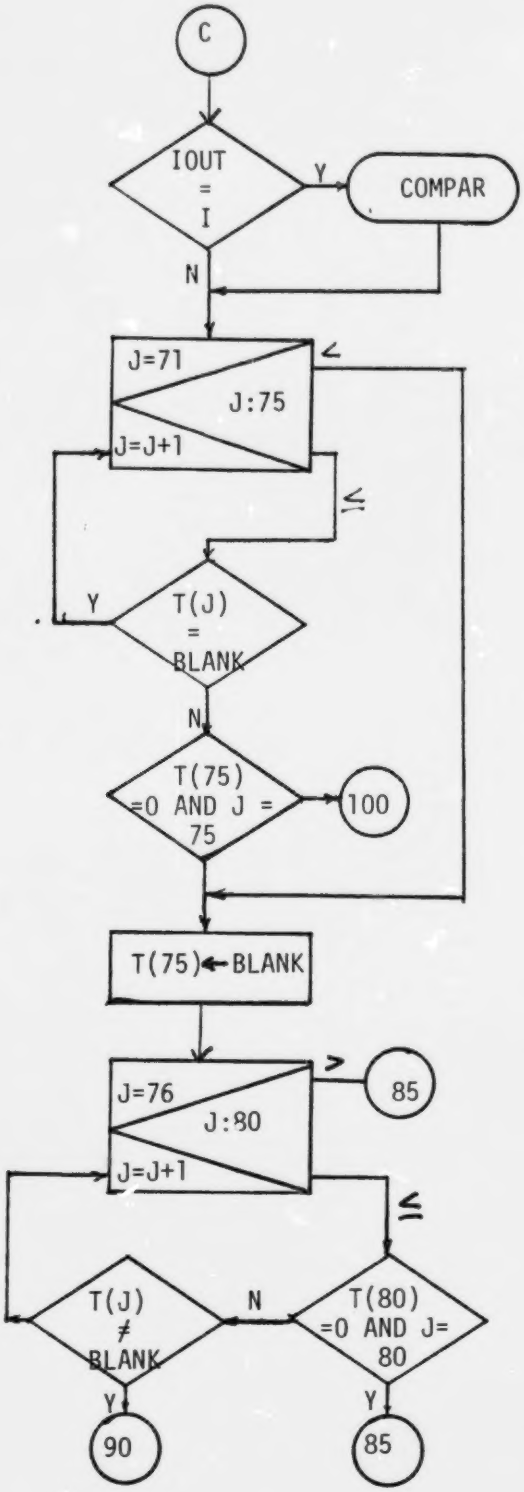

CARD 4
I=1
I:80
I=I+1
>
≤
TEMP(I)=BLANK
CARD ← 3
MISTAK ← 0
J ← 6
I ← 1
IOUT = 1
Y
N
COMPAR
J ← 11
IOUT = 1
COMPAR
A
A
J ← 16
I ← 2
IOUT = 1
Y
COMPAR
N
ITYPE=BLANK
IGEO = 0
T(26) = BLANK
Y
25
N
EXCL RIGHT TURN LANE
Y
55
N
15
I=26
I:31
I=I+1
>
MISTAK ← 1
≤
65
TEMP(I) ← '-'

CARD 4

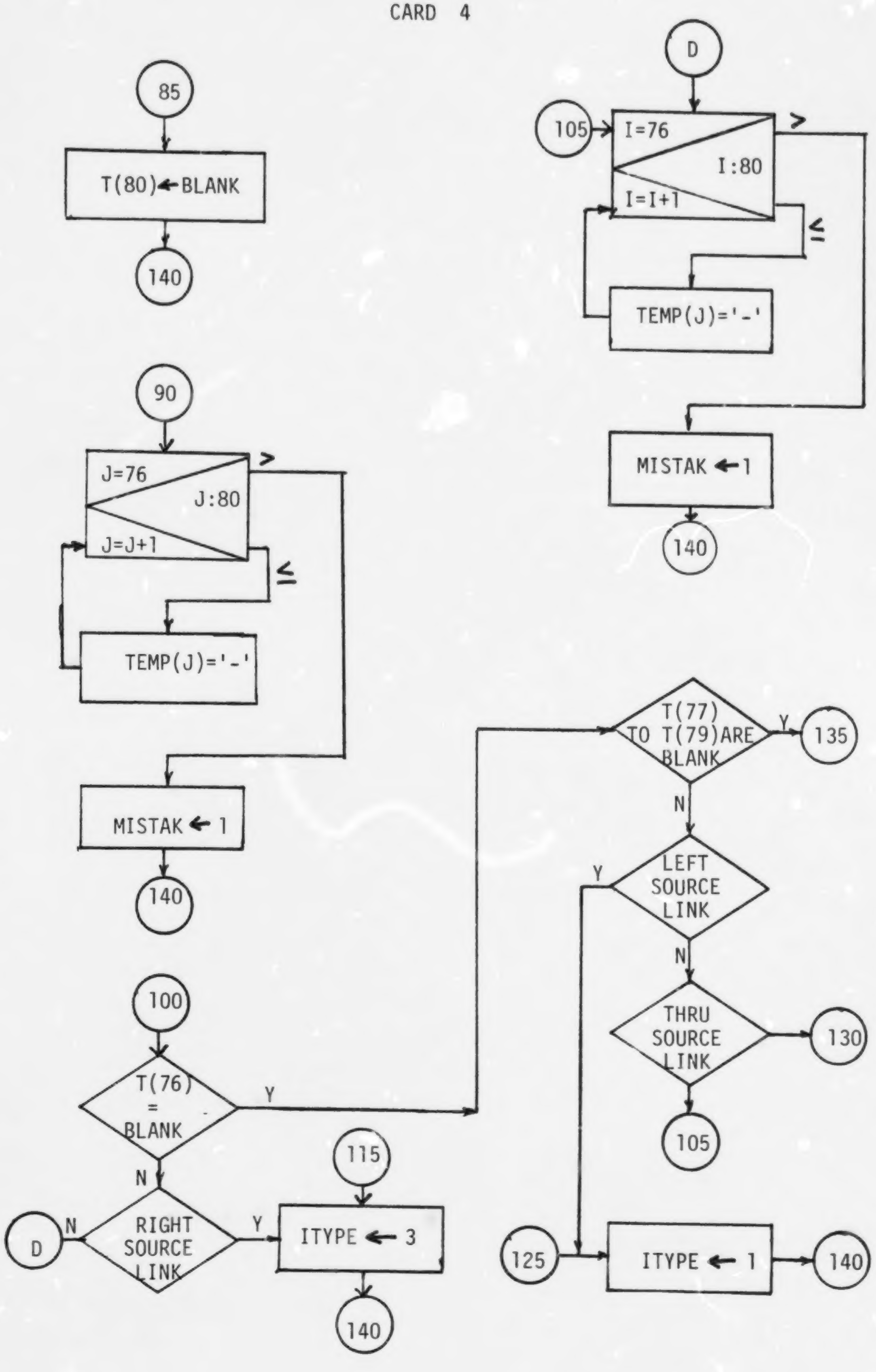

25
T(27) = BLANK
Y
N
BOTH EXCLUSIVE LANES
Y
N
EXCL LEFT TURN LANE
Y
N
15
30
IGEO ← 3
65
IGEO ← 1
35
65
T(28) = BLANK
Y
N
ONE WAY
Y
15
N
45
IGEO ← 5
65
T(29) ≠ BLANK
Y
15
N
T(30) = 0
Y
45
N
T(30) = B
Y
30
N
T(30) = L
Y
35
N
B

CARD 4

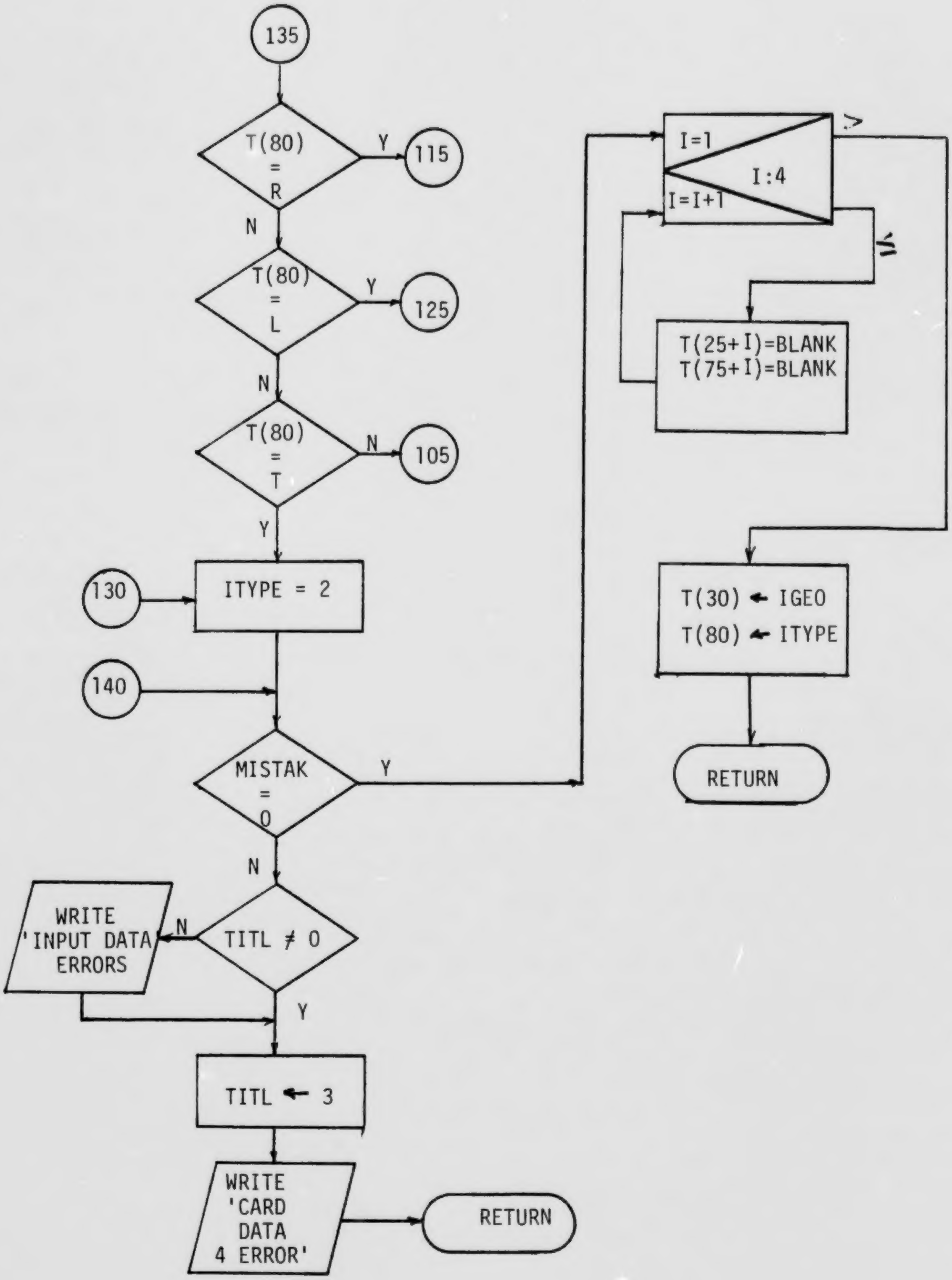

B
T(30) = R
Y
N
T(30) = T
Y
N
T(30) = 0
Y
N
T(30) = BLANK
Y
15
N
55
IGEO ← 2
IGEO ← 4
J ← 31
I ← 9
65
C


C
IOUT = I
Y
COMPAR
N
J=71
J:75
J=J+1
<
≤
T(J) = BLANK
Y
N
T(75) =0 AND J = 75
100
T(75)←BLANK
J=76
J:80
J=J+1
>
85
≤
T(80) =0 AND J= 80
N
T(J) ≠ BLANK
Y
90
Y
85

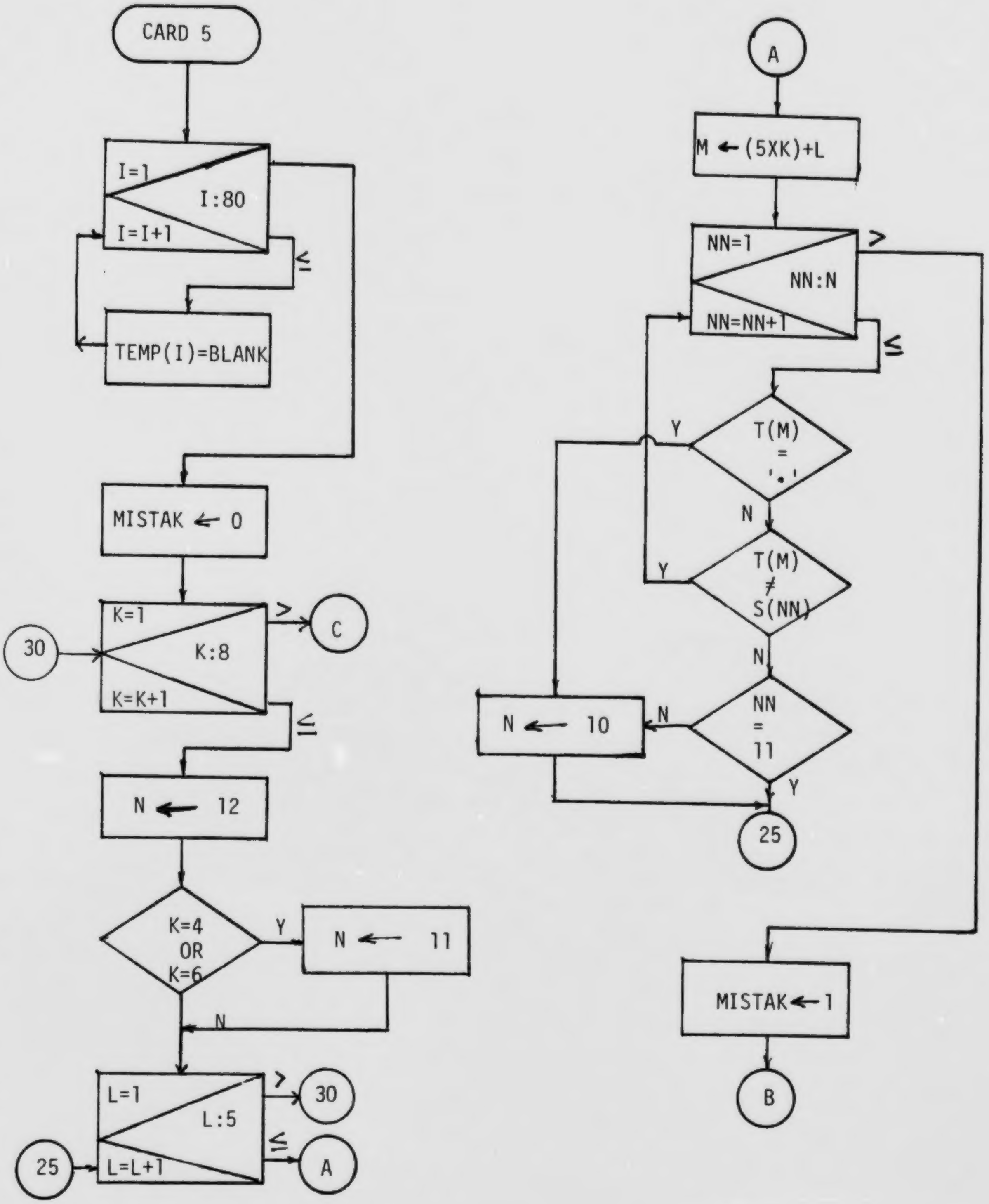
CARD 4


85
T(80)←BLANK
140
90
J=76
J:80
J=J+1
>
≤
TEMP(J)='-'
MISTAK ← 1
140
100
T(76) = BLANK
Y
N
D
N
RIGHT SOURCE LINK
Y
115
ITYPE ← 3
140
D
105
I=76
I:80
I=I+1
>
≤
TEMP(J)='-'
MISTAK ←1
140
T(77) TO T(79) ARE BLANK
Y
135
N
LEFT SOURCE LINK
Y
N
THRU SOURCE LINK
130
105
125
ITYPE ← 1
140

CARD 4

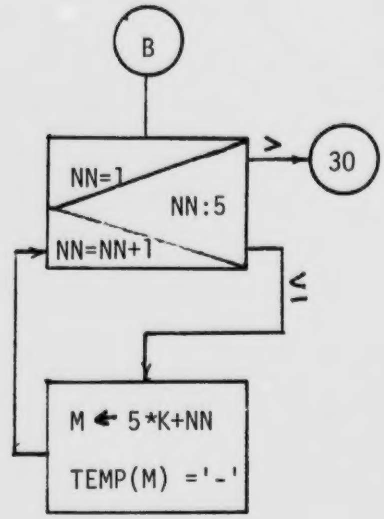

135
T(80) = R
Y
115
N
T(80) = L
Y
125
N
T(80) = T
N
105
Y
130
ITYPE = 2
140
MISTAK = 0
Y
N
TITL ≠ 0
N
WRITE 'INPUT DATA ERRORS
Y
TITL ← 3
WRITE 'CARD DATA 4 ERROR'
RETURN
I=1
I:4
I=I+1
>
≤
T(25+I)=BLANK
T(75+I)=BLANK
T(30) ← IGEO
T(80) ← ITYPE
RETURN

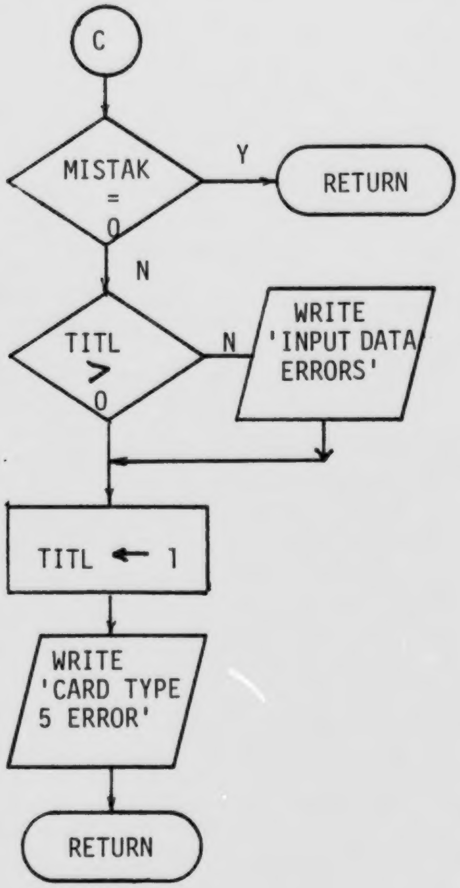
CARD 5 SUBROUTINE



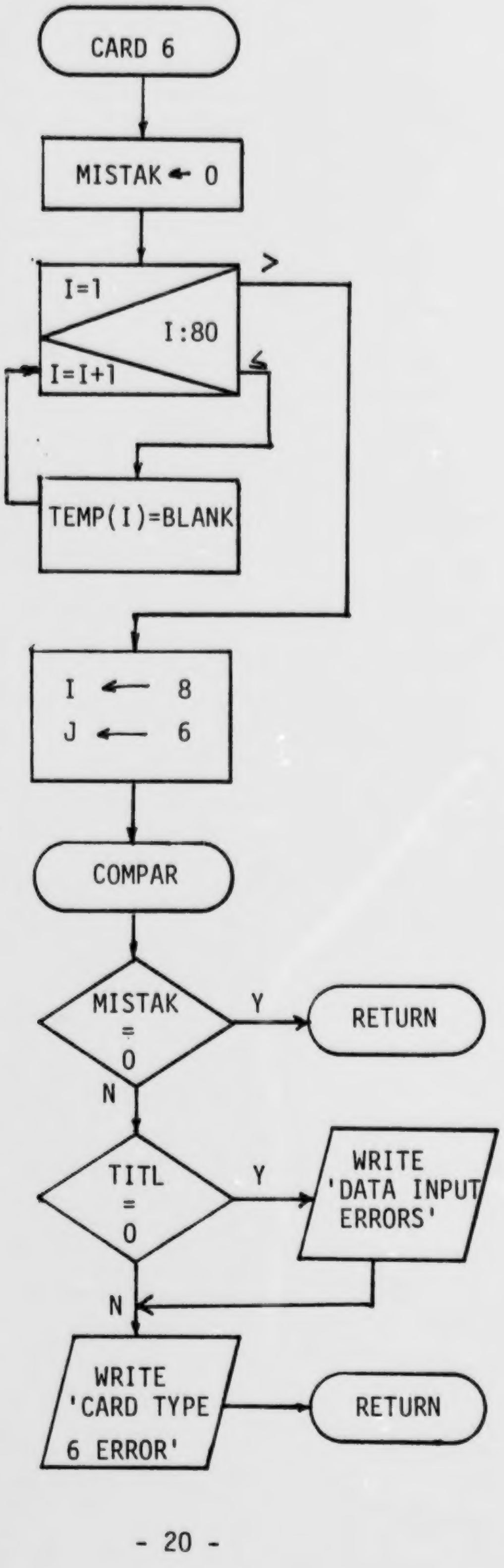
CARD 5
I=1
I:80
I=I+1
≤
TEMP(I)=BLANK
MISTAK ← 0
K=1
K:8
K=K+1
>
C
30
≤
N ← 12
K=4 OR K=6
Y
N ← 11
N
L=1
L:5
L=L+1
>
30
≤
A
25
A
M ← (5XK)+L
NN=1
NN:N
NN=NN+1
>
≤
T(M) = '.'
Y
N
T(M) ≠ S(NN)
Y
N
NN = 11
N
N ← 10
Y
25
MISTAK ← 1
B

CARD 5

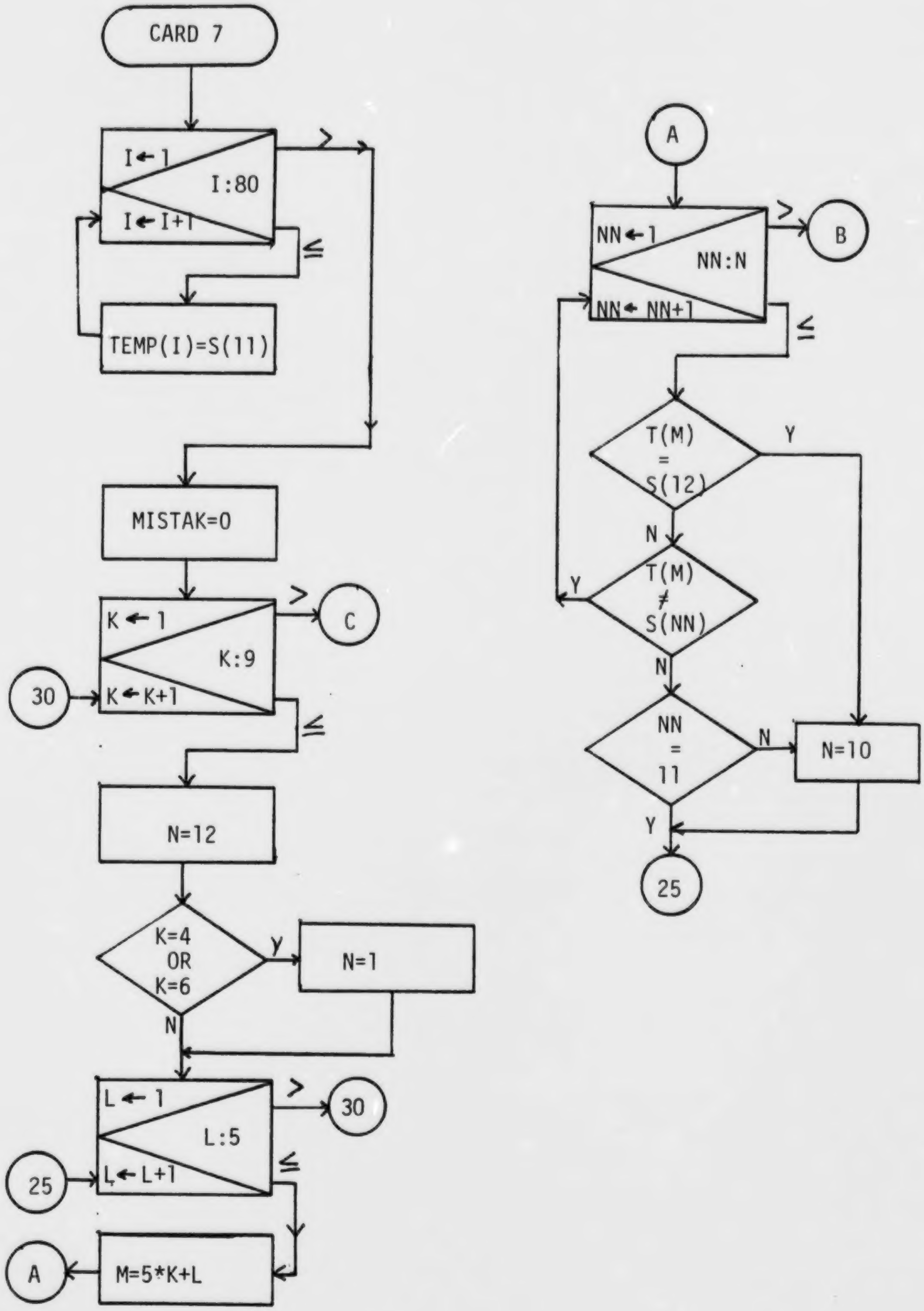

B
>
30
NN=1
NN:5
NN=NN+1
≤
M ← 5*K+NN
TEMP(M) ='-'


C
MISTAK
=
0
Y
RETURN
N
TITL
>
0
N
WRITE
'INPUT DATA
ERRORS'
TITL ← 1
WRITE
'CARD TYPE
5 ERROR'
RETURN

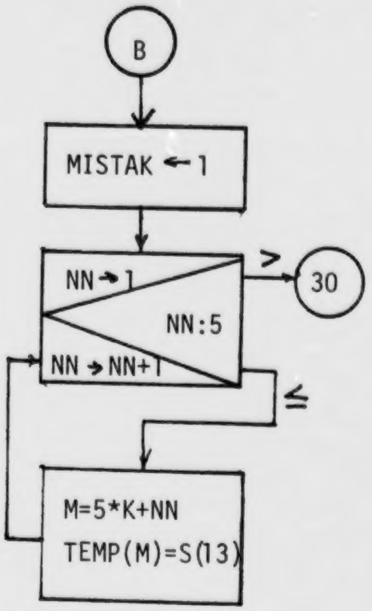
CARD 6 SUBROUTINE

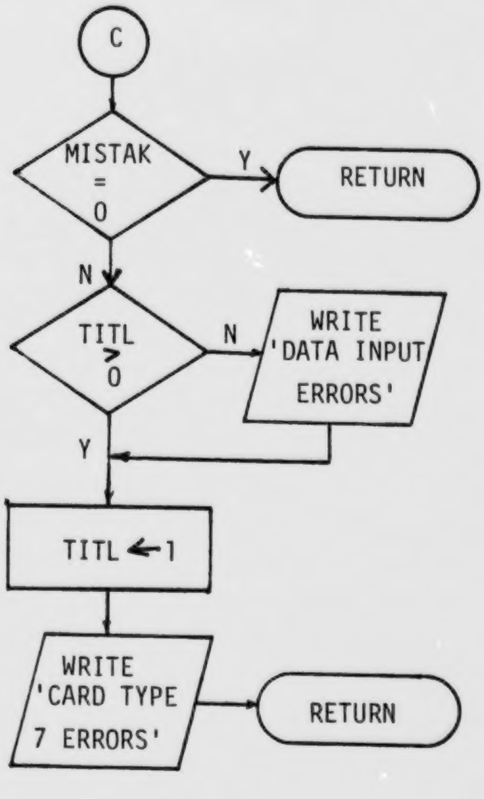

CARD 6
MISTAK ← 0
I=1
I:80
>
≤
I=I+1
TEMP(I)=BLANK
I ← 8
J ← 6
COMPAR
MISTAK = 0
Y
RETURN
N
TITL = 0
Y
WRITE 'DATA INPUT ERRORS'
N
WRITE 'CARD TYPE 6 ERROR'
RETURN

CARD 7 SUBROUTINE

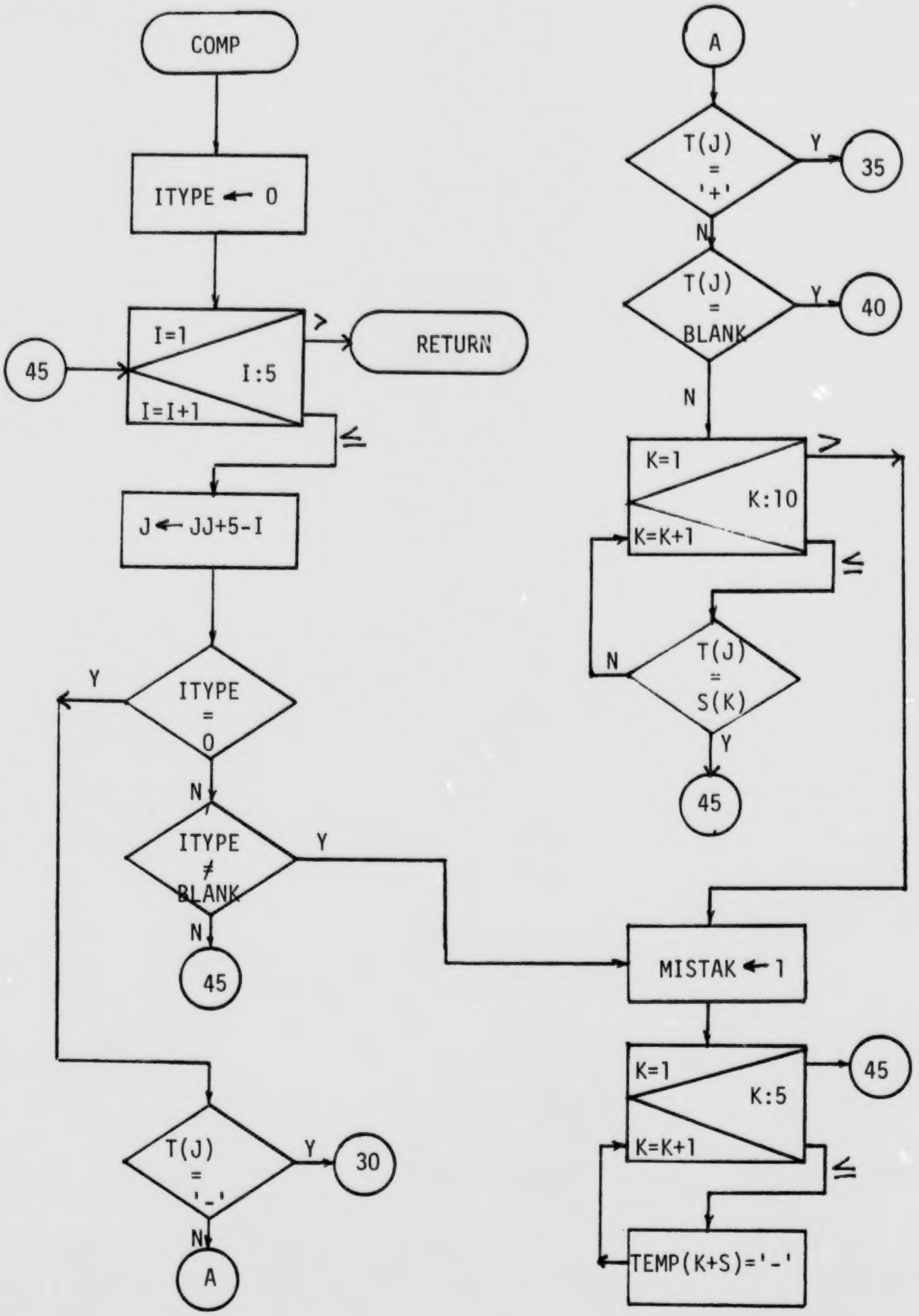

CARD 7
I ← 1
I:80
I ← I+1
>
≤
TEMP(I)=S(11)
MISTAK=0
K ← 1
K:9
K ← K+1
>
C
30
≤
N=12
K=4 OR K=6
Y
N=1
N
L ← 1
L:5
L ← L+1
>
30
25
≤
M=5*K+L
A
A
NN ← 1
NN:N
NN ← NN+1
>
B
≤
T(M) = S(12)
Y
N
T(M) ≠ S(NN)
Y
N
NN = 11
N
N=10
Y
25

CARD 7

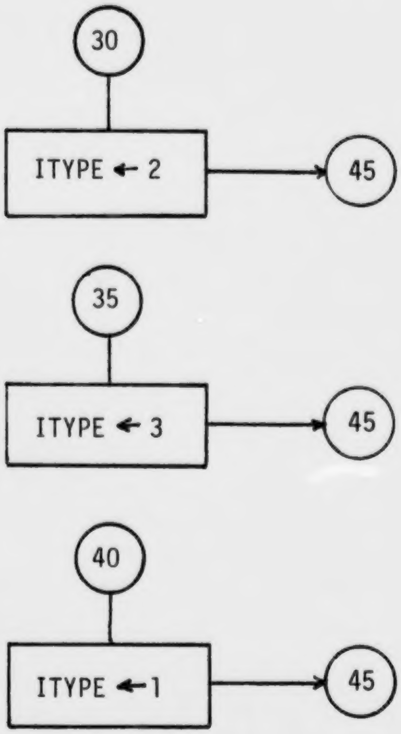

B
MISTAK ← 1
NN → 1
NN:5
NN → NN+1
>
30
≤
M=5*K+NN
TEMP(M)=S(13)


C
MISTAK = 0
Y
RETURN
N
TITL > 0
N
WRITE 'DATA INPUT ERRORS'
Y
TITL ← 1
WRITE 'CARD TYPE 7 ERRORS'
RETURN

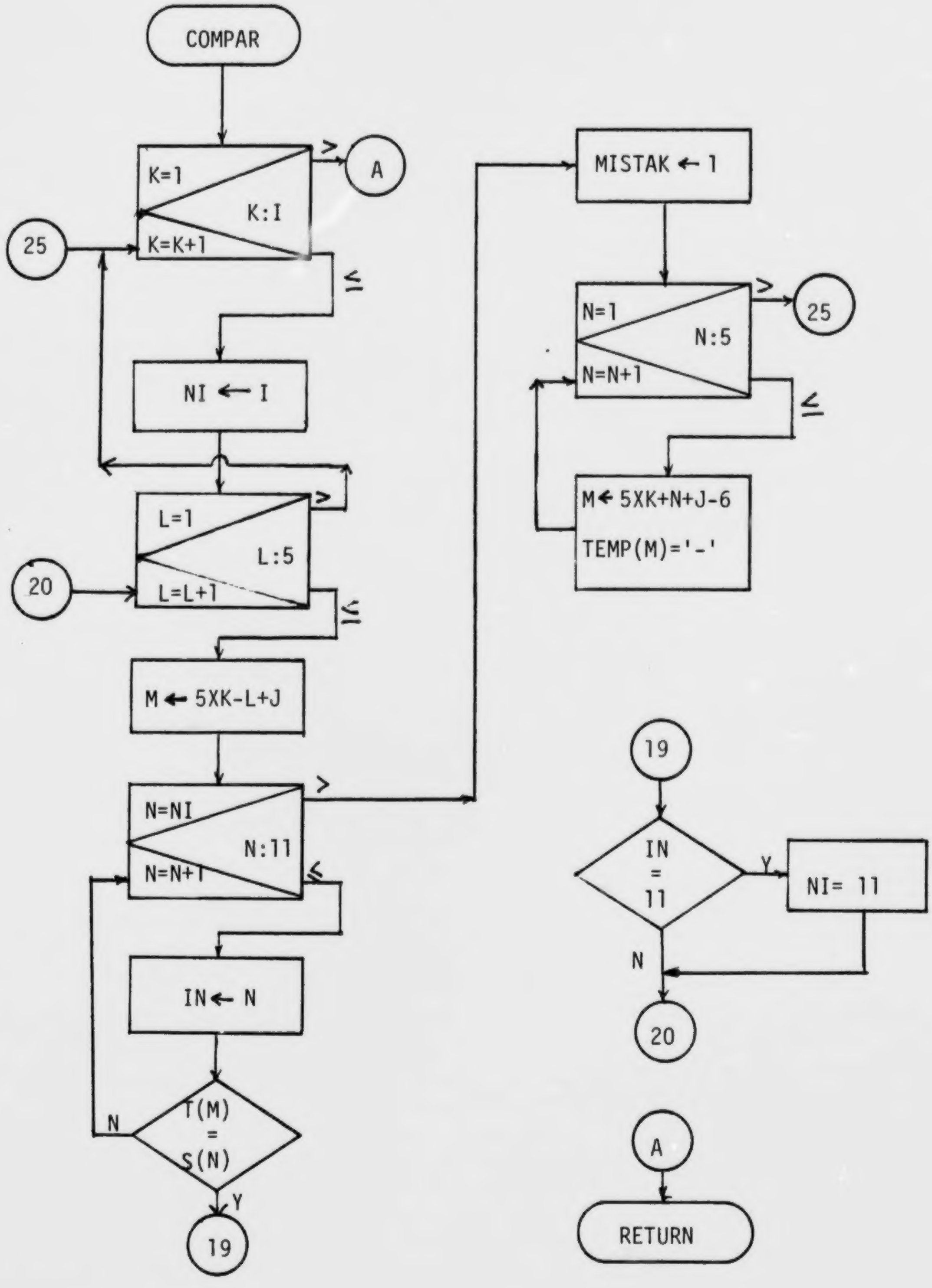
COMP SUBROUTINE


COMP
ITYPE ← 0
45
I=1
I:5
I=I+1
>
RETURN
≤
J ← JJ+5-I
ITYPE = 0
Y
N
ITYPE ≠ BLANK
Y
N
45
T(J) = '-'
Y
30
N
A
A
T(J) = '+'
Y
35
N
T(J) = BLANK
Y
40
N
K=1
K:10
K=K+1
>
≤
T(J) = S(K)
N
Y
45
MISTAK ← 1
K=1
K:5
K=K+1
45
≤
TEMP(K+S)='-'

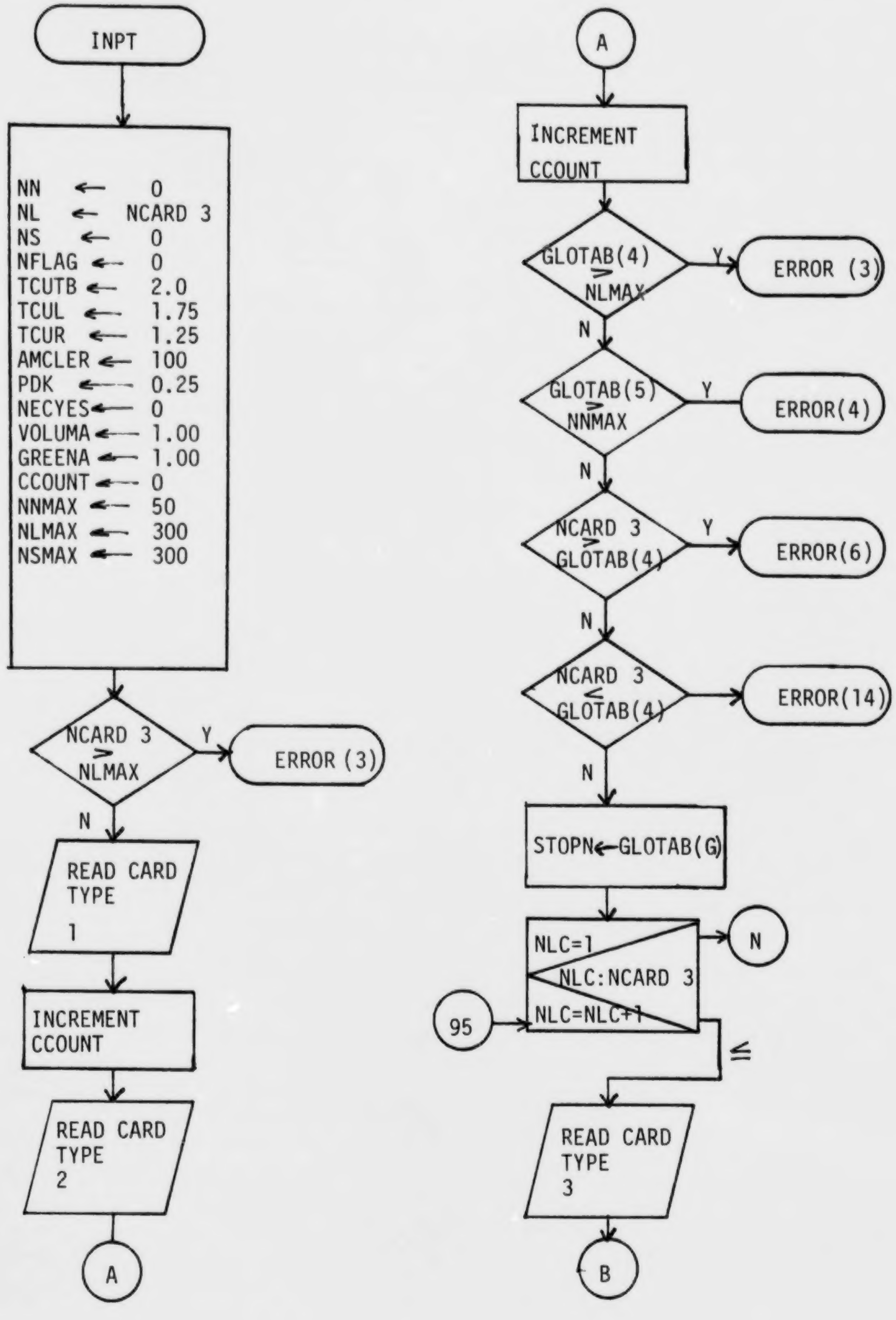
COMP


30
ITYPE ← 2
45
35
ITYPE ← 3
45
40
ITYPE ← 1
45

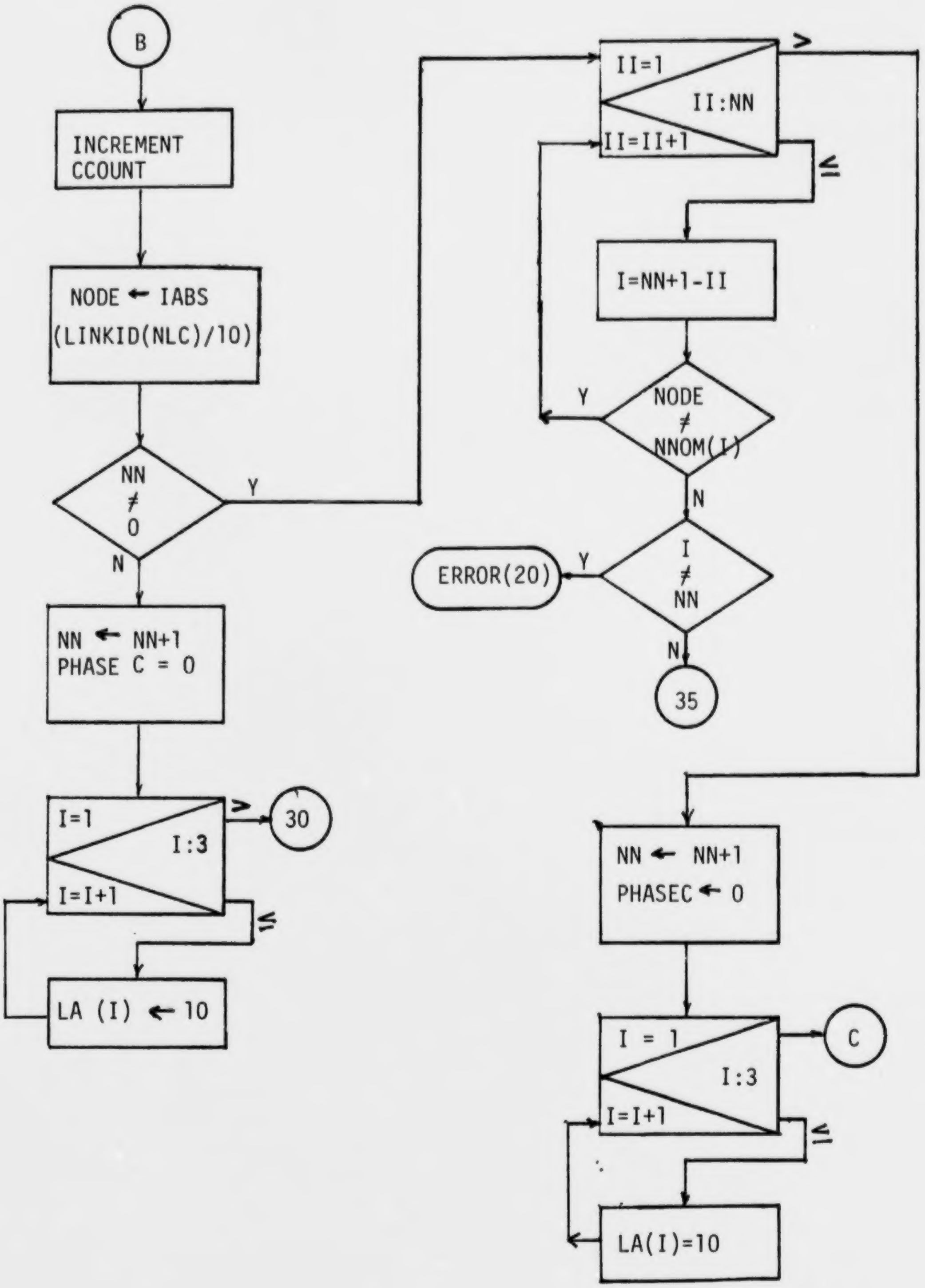
COMPAR SUBROUTINE

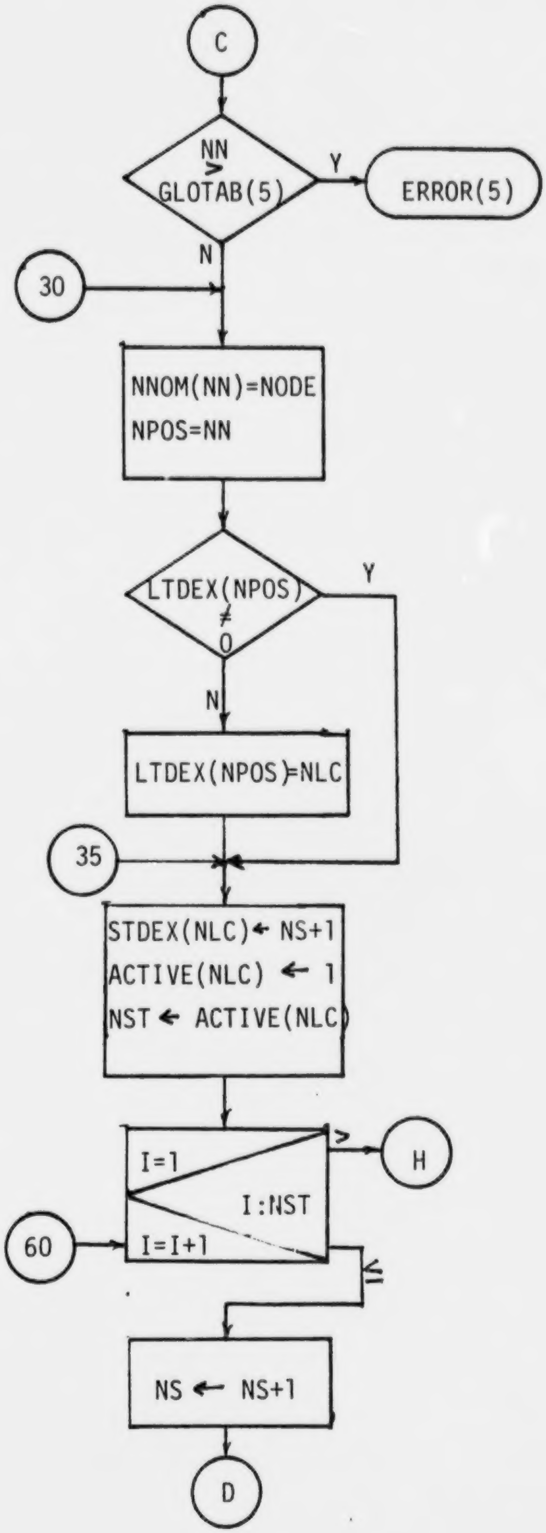

COMPAR
K=1
K:I
K=K+1
>
A
25
≤
NI ← I
L=1
L:5
L=L+1
>
20
≤
M ← 5XK-L+J
N=NI
N:11
N=N+1
>
≤
IN ← N
T(M) = S(N)
N
Y
19
MISTAK ← 1
N=1
N:5
N=N+1
>
25
≤
M ← 5XK+N+J-6
TEMP(M)='-'
19
IN = 11
Y
NI= 11
N
20
A
RETURN

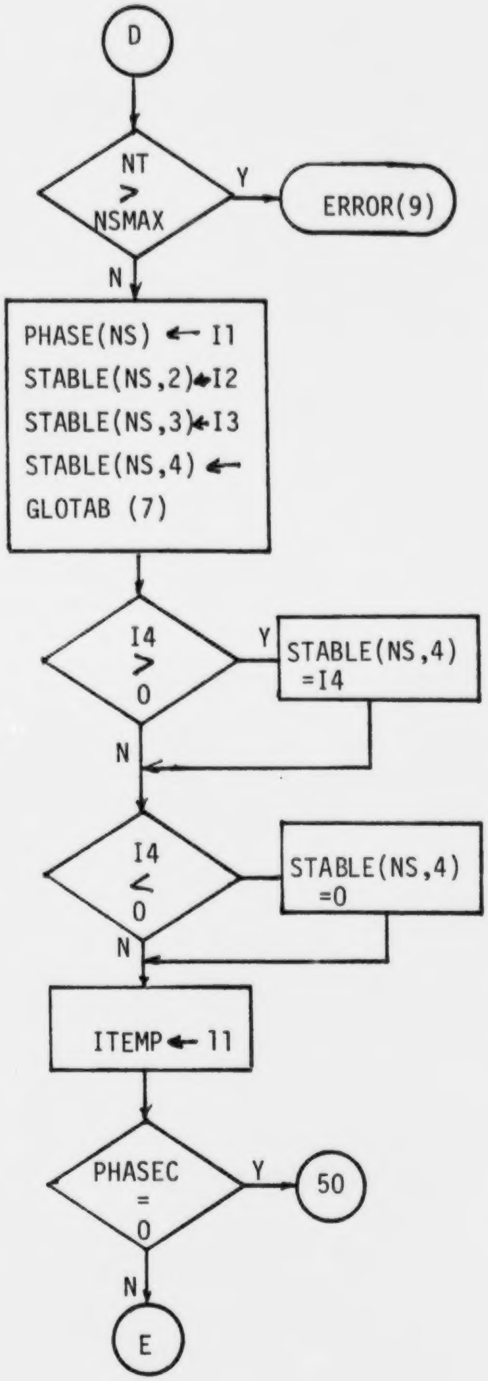
INPT SUBROUTINE


INPT
NN ← 0
NL ← NCARD 3
NS ← 0
NFLAG ← 0
TCUTB ← 2.0
TCUL ← 1.75
TCUR ← 1.25
AMCLER ← 100
PDK ← 0.25
NECYES ← 0
VOLUMA ← 1.00
GREENA ← 1.00
CCOUNT ← 0
NNMAX ← 50
NLMAX ← 300
NSMAX ← 300
NCARD 3 > NLMAX
Y
ERROR (3)
N
READ CARD TYPE 1
INCREMENT CCOUNT
READ CARD TYPE 2
A
A
INCREMENT CCOUNT
GLOTAB(4) > NLMAX
Y
ERROR (3)
N
GLOTAB(5) > NNMAX
Y
ERROR(4)
N
NCARD 3 GLOTAB(4)
Y
ERROR(6)
N
NCARD 3 < GLOTAB(4)
ERROR(14)
N
STOPN ← GLOTAB(G)
NLC=1
NLC:NCARD 3
NLC=NLC+1
N
95
≤
READ CARD TYPE 3
B

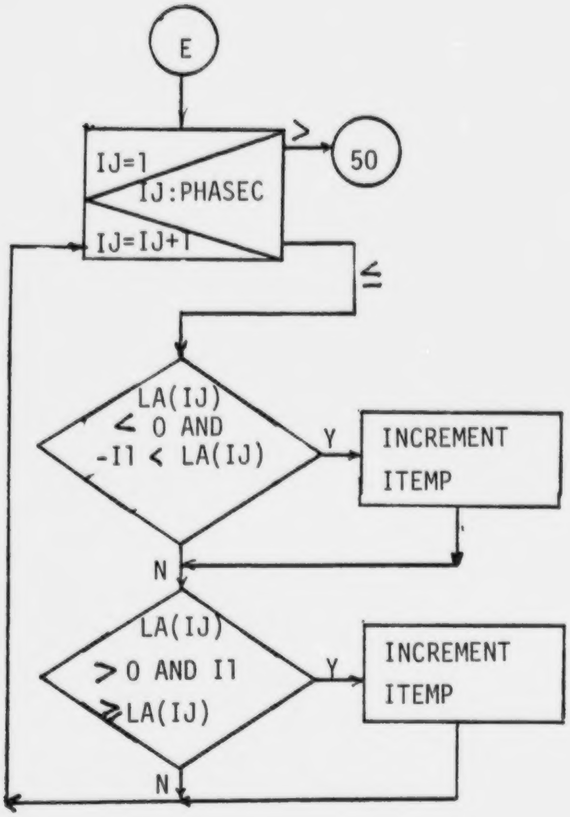
INPT

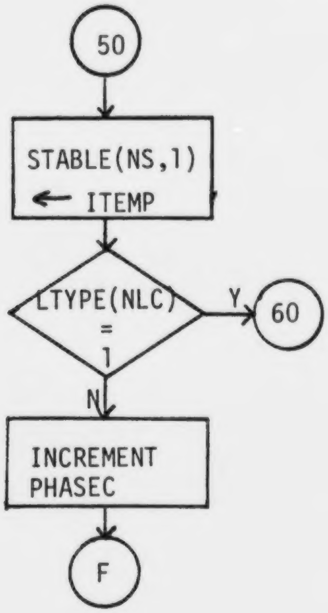

B
INCREMENT CCOUNT
NODE ← IABS (LINKID(NLC)/10)
NN ≠ 0
Y
N
NN ← NN+1
PHASE C = 0
I=1
I:3
I=I+1
>
≤
30
LA (I) ← 10
II=1
II:NN
II=II+1
>
≤
I=NN+1-II
NODE ≠ NNOM(I)
Y
N
I ≠ NN
Y
ERROR(20)
N
35
NN ← NN+1
PHASEC ← 0
I = 1
I:3
I=I+1
≤
C
LA(I)=10

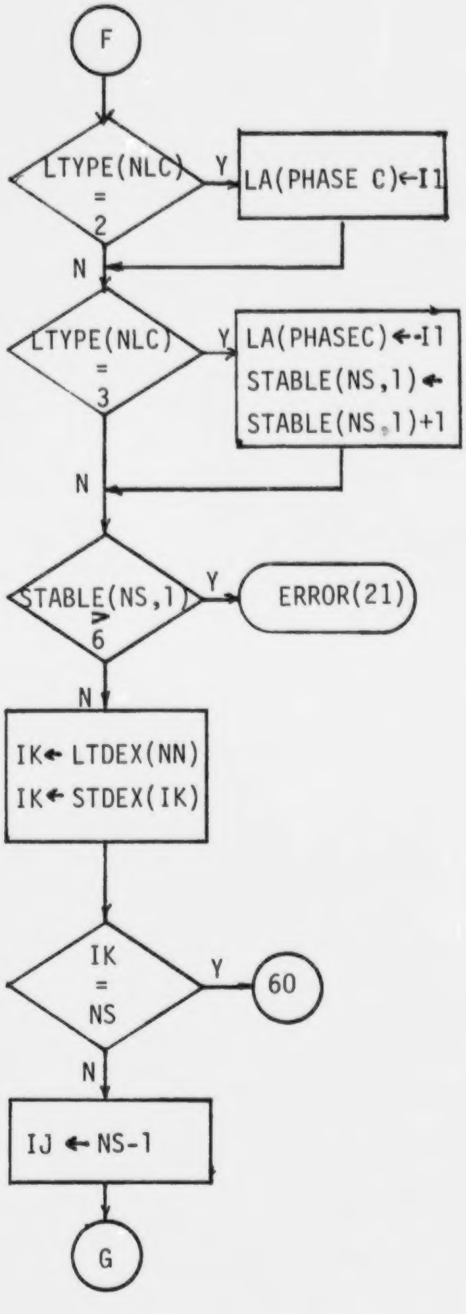

C
NN > GLOTAB(5)
Y
ERROR(5)
N
30
NNOM(NN)=NODE
NPOS=NN
LTDEX(NPOS) ≠ 0
Y
N
LTDEX(NPOS)=NLC
35
STDEX(NLC) ← NS+1
ACTIVE(NLC) ← 1
NST ← ACTIVE(NLC)
I=1
I:NST
>
H
60
I=I+1
≤
NS ← NS+1
D


D
NT > NSMAX
Y
ERROR(9)
N
PHASE(NS) ← I1
STABLE(NS,2) ← I2
STABLE(NS,3) ← I3
STABLE(NS,4) ← GLOTAB (7)
I4 > 0
Y
STABLE(NS,4) =I4
N
I4 < 0
STABLE(NS,4) =0
N
ITEMP ← 11
PHASEC = 0
Y
50
N
E

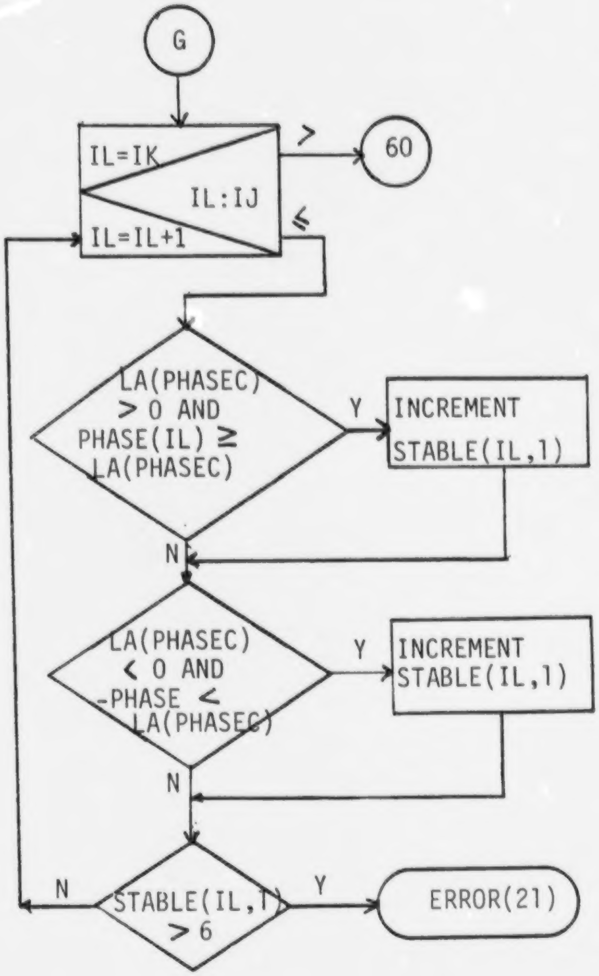
INPT

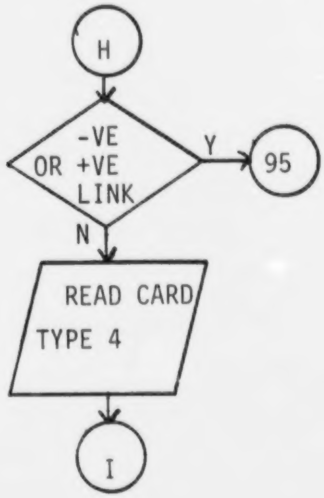

E
IJ=1
IJ:PHASEC
IJ=IJ+1
>
50
≤
LA(IJ) < 0 AND -I1 < LA(IJ)
Y
INCREMENT ITEMP
N
LA(IJ) > 0 AND I1 ≥ LA(IJ)
Y
INCREMENT ITEMP
N

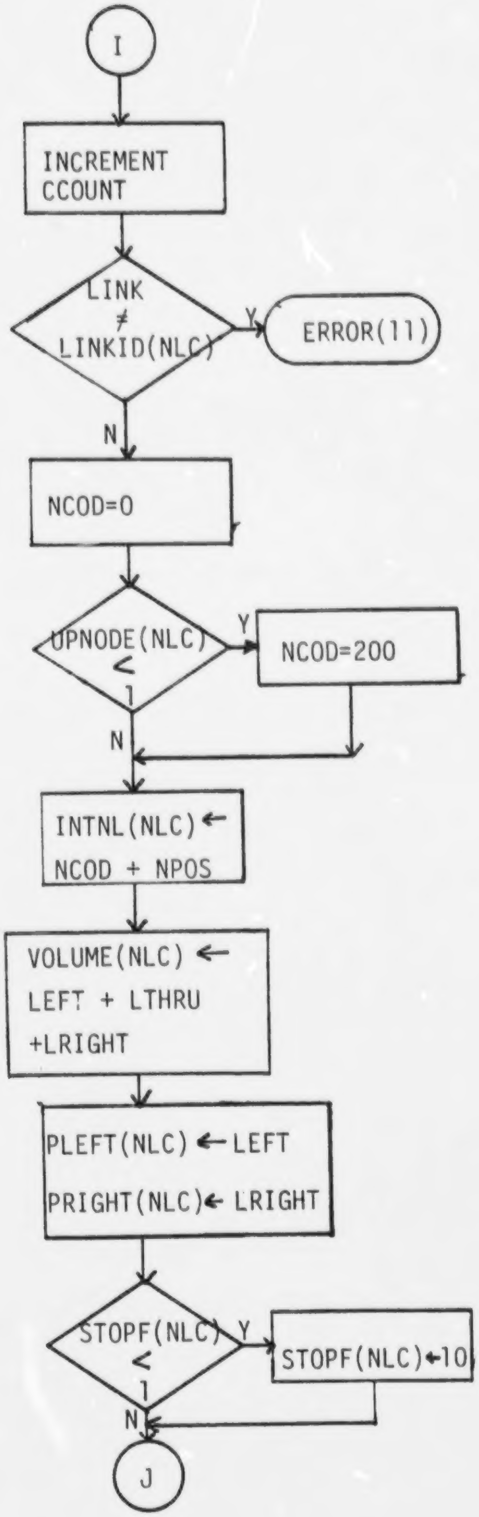

50
STABLE(NS,1) ← ITEMP
LTYPE(NLC) = 1
Y
60
N
INCREMENT PHASEC
F


F
LTYPE(NLC) = 2
Y
LA(PHASE C)←I1
N
LTYPE(NLC) = 3
Y
LA(PHASEC) ←-I1
STABLE(NS,1) ←
STABLE(NS,1)+1
N
STABLE(NS,1) > 6
Y
ERROR(21)
N
IK← LTDEX(NN)
IK← STDEX(IK)
IK = NS
Y
60
N
IJ ← NS-1
G

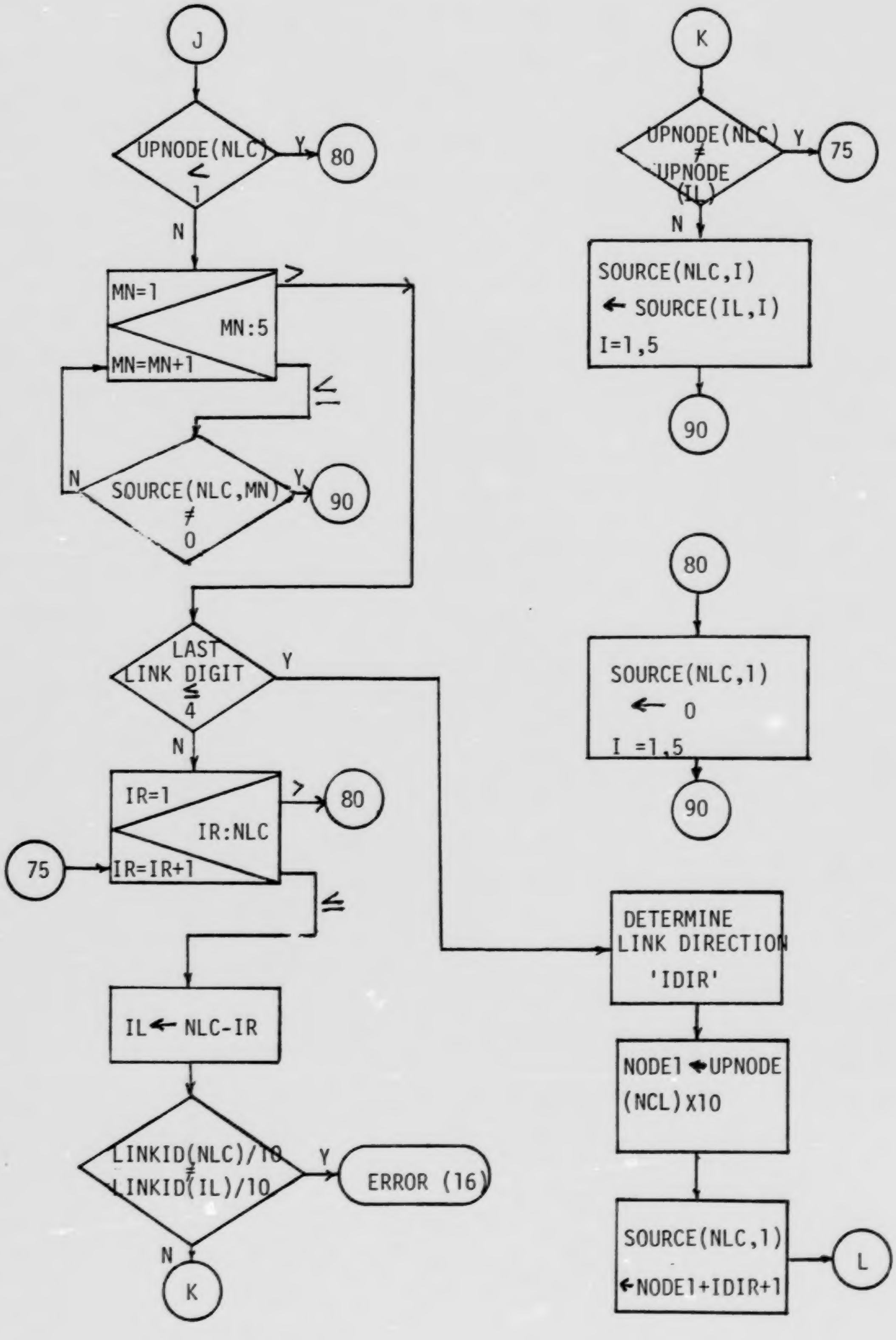
INPT


G
IL=IK
IL:IJ
IL=IL+1
>
60
≤
LA(PHASEC) > 0 AND PHASE(IL) ≥ LA(PHASEC)
Y
INCREMENT STABLE(IL,1)
N
LA(PHASEC) < 0 AND -PHASE < LA(PHASEC)
Y
INCREMENT STABLE(IL,1)
N
STABLE(IL,1) > 6
N
Y
ERROR(21)

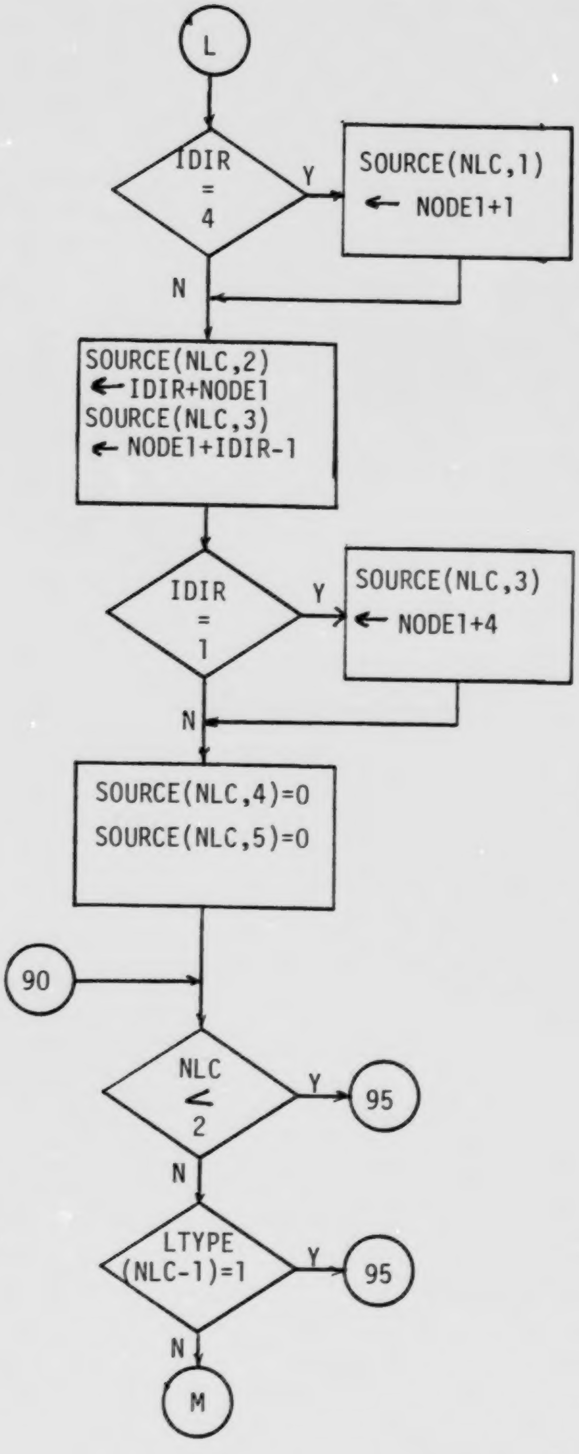

H
-VE OR +VE LINK
Y
95
N
READ CARD TYPE 4
I

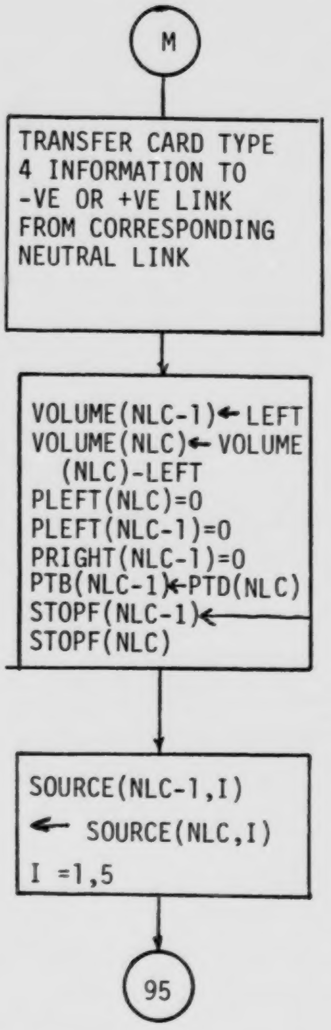

I
INCREMENT CCOUNT
LINK ≠ LINKID(NLC)
Y
ERROR(11)
N
NCOD=0
UPNODE(NLC) < 1
Y
NCOD=200
N
INTNL(NLC) ← NCOD + NPOS
VOLUME(NLC) ← LEFT + LTHRU +LRIGHT
PLEFT(NLC) ← LEFT
PRIGHT(NLC) ← LRIGHT
STOPF(NLC) < 1
Y
STOPF(NLC) ← 10
N
J

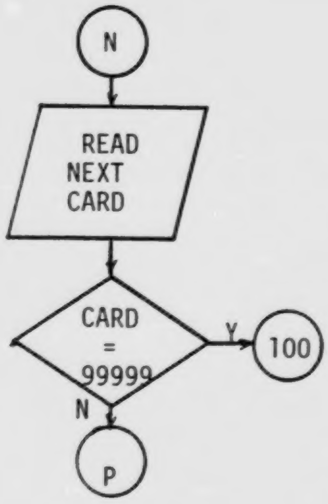
INPT



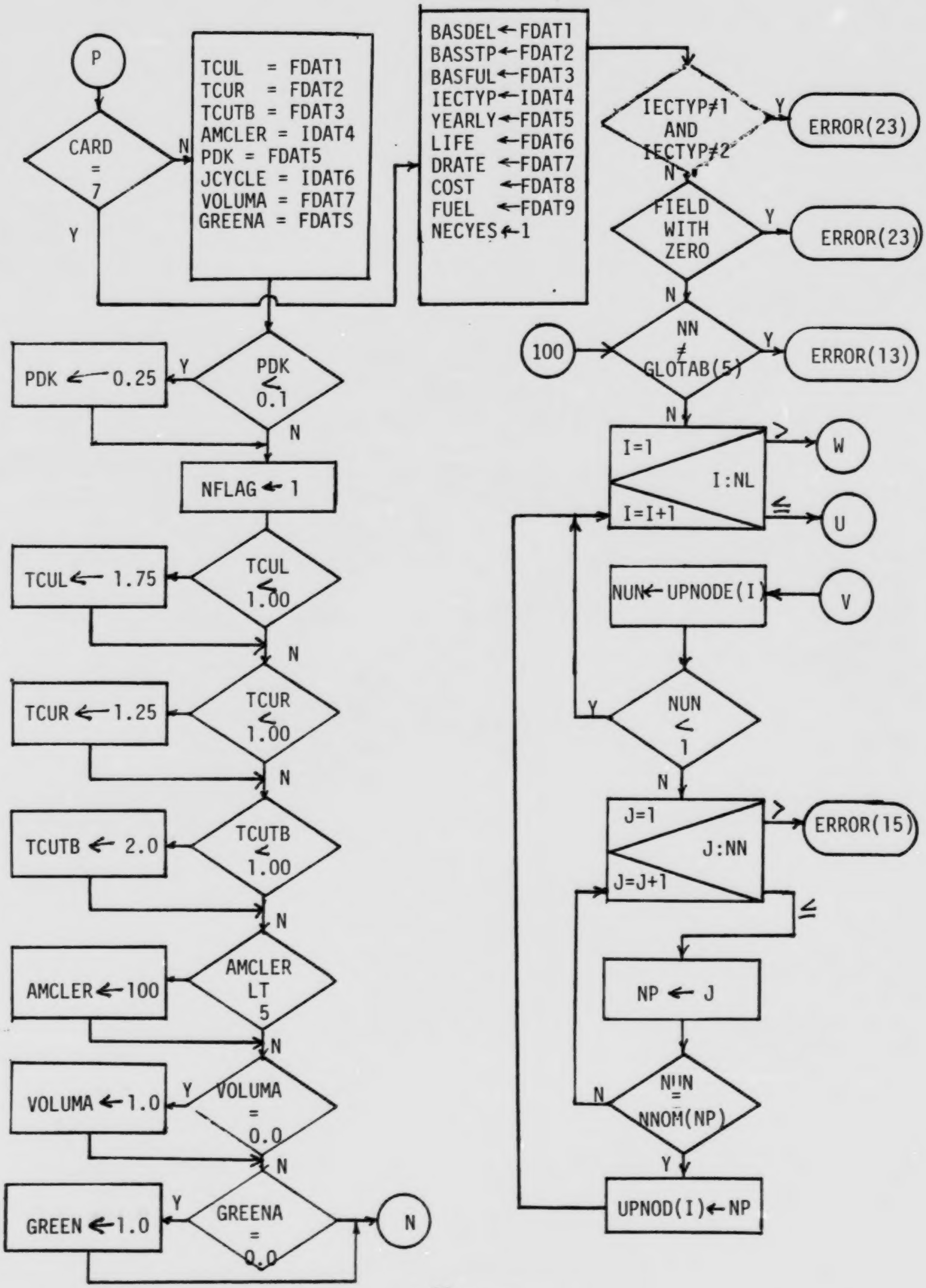
J
UPNODE(NLC) < 1
Y
80
N
MN=1
MN:5
MN=MN+1
>
≤
SOURCE(NLC,MN) ≠ 0
N
Y
90
LAST LINK DIGIT ≤ 4
Y
N
IR=1
IR:NLC
IR=IR+1
>
80
75
≤
IL ← NLC-IR
LINKID(NLC)/10 ≠ LINKID(IL)/10
Y
ERROR (16)
N
K
K
UPNODE(NLC) ≠ UPNODE (IL)
Y
75
N
SOURCE(NLC,I) ← SOURCE(IL,I) I=1,5
90
80
SOURCE(NLC,1) ← 0 I =1,5
90
DETERMINE LINK DIRECTION 'IDIR'
NODE1 ← UPNODE (NCL) X10
SOURCE(NLC,1) ← NODE1+IDIR+1
L


L
IDIR = 4
Y
SOURCE(NLC,1) ← NODE1+1
N
SOURCE(NLC,2) ← IDIR+NODE1
SOURCE(NLC,3) ← NODE1+IDIR-1
IDIR = 1
Y
SOURCE(NLC,3) ← NODE1+4
N
SOURCE(NLC,4)=0
SOURCE(NLC,5)=0
90
NLC < 2
Y
95
N
LTYPE (NLC-1)=1
Y
95
N
M


M
TRANSFER CARD TYPE 4 INFORMATION TO -VE OR +VE LINK FROM CORRESPONDING NEUTRAL LINK
VOLUME(NLC-1) ← LEFT
VOLUME(NLC) ← VOLUME (NLC)-LEFT
PLEFT(NLC)=0
PLEFT(NLC-1)=0
PRIGHT(NLC-1)=0
PTB(NLC-1) ← PTD(NLC)
STOPF(NLC-1) ←
STOPF(NLC)
SOURCE(NLC-1,I) ← SOURCE(NLC,I)
I =1,5
95

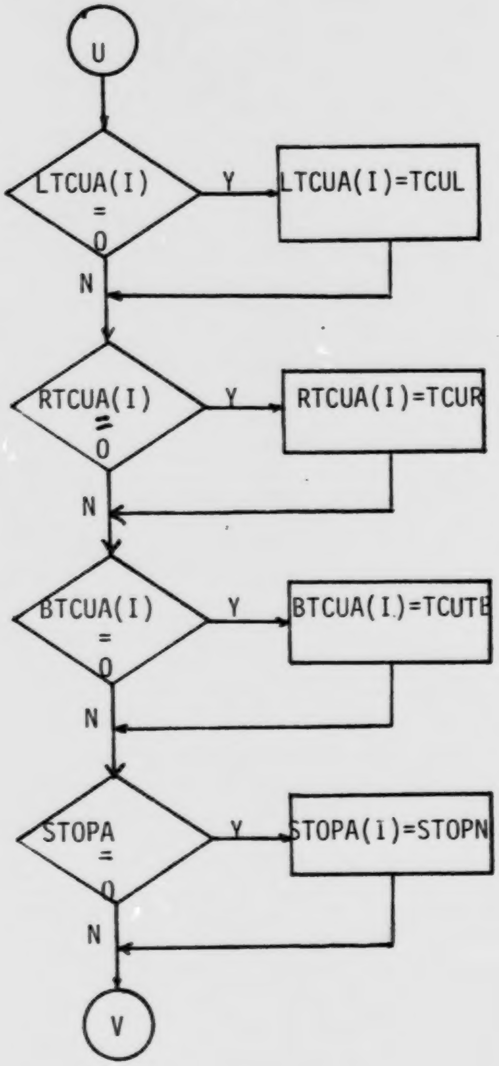

N
READ NEXT CARD
CARD = 99999
Y
100
N
P

INPT

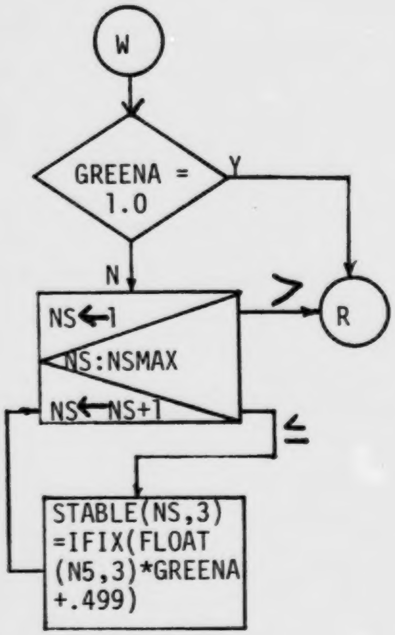


P
CARD = 7
Y
N
TCUL = FDAT1
TCUR = FDAT2
TCUTB = FDAT3
AMCLER = IDAT4
PDK = FDAT5
JCYCLE = IDAT6
VOLUMA = FDAT7
GREENA = FDATS
BASDEL ← FDAT1
BASSTP ← FDAT2
BASFUL ← FDAT3
IECTYP ← IDAT4
YEARLY ← FDAT5
LIFE ← FDAT6
DRATE ← FDAT7
COST ← FDAT8
FUEL ← FDAT9
NECYES ← 1
IECTYP≠1 AND IECTYP≠2
Y
ERROR(23)
N
FIELD WITH ZERO
Y
ERROR(23)
N
100
NN ≠ GLOTAB(5)
Y
ERROR(13)
N
I=1
I:NL
I=I+1
>
W
≤
U
PDK ← 0.25
Y
PDK < 0.1
N
NFLAG ← 1
TCUL ← 1.75
TCUL < 1.00
N
TCUR ← 1.25
TCUR < 1.00
N
TCUTB ← 2.0
TCUTB < 1.00
N
AMCLER ← 100
AMCLER LT 5
N
VOLUMA ← 1.0
Y
VOLUMA = 0.0
N
GREEN ← 1.0
Y
GREENA = 0.0
N
NUN ← UPNODE(I)
V
Y
NUN < 1
N
J=1
J:NN
J=J+1
>
ERROR(15)
≤
NP ← J
N
NUN = NNOM(NP)
Y
UPNOD(I) ← NP

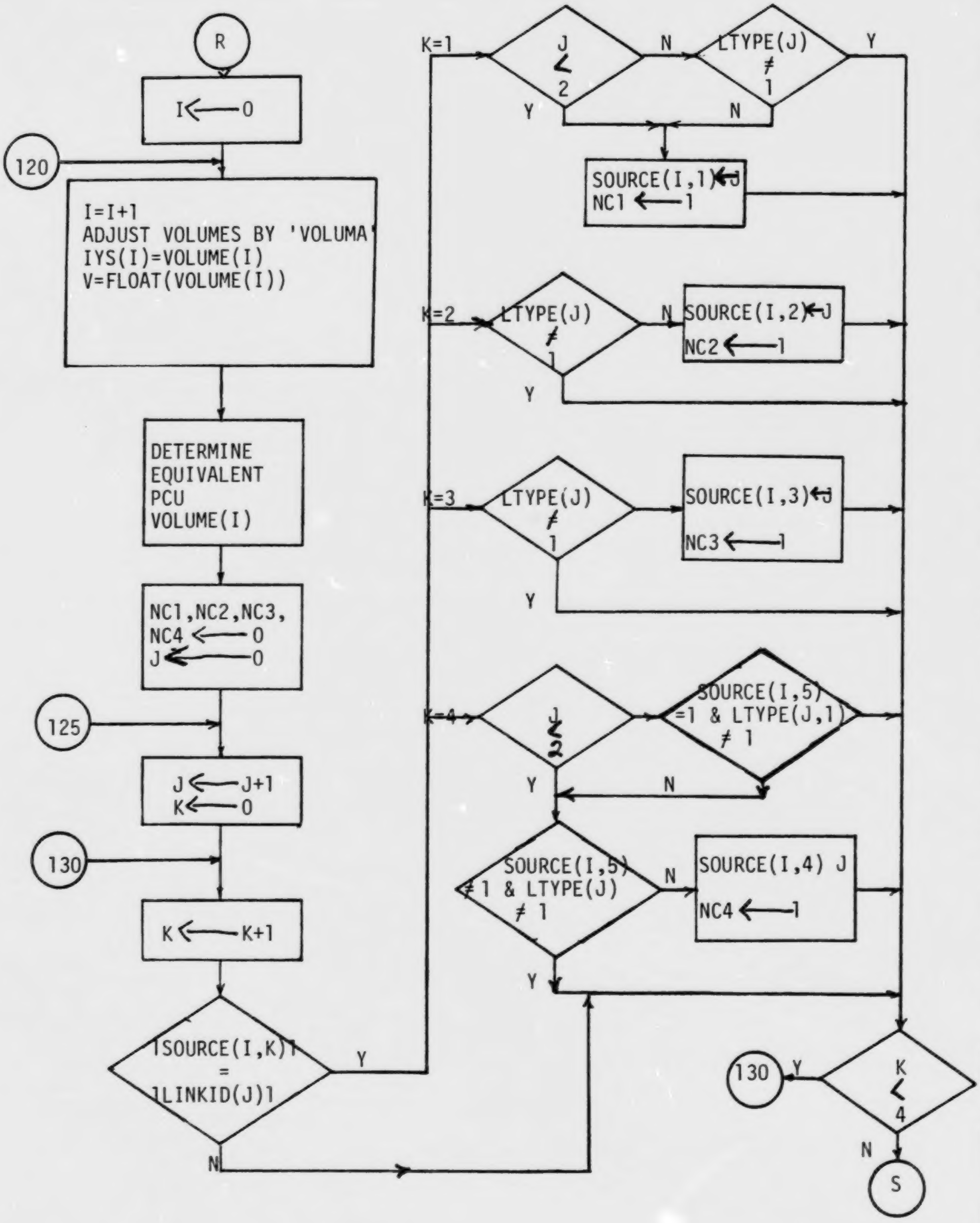
INPT



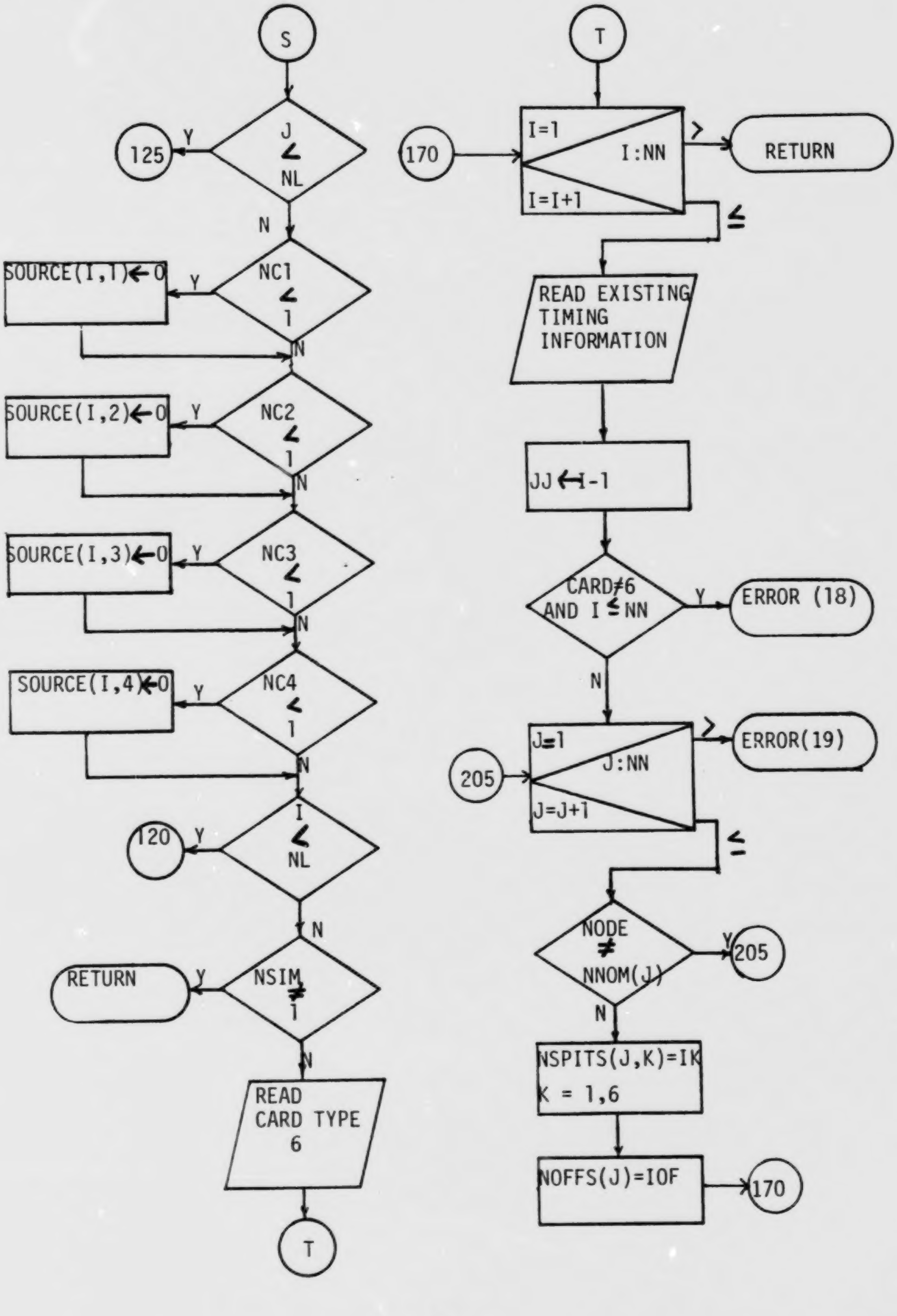
U
LTCUA(I) = 0
Y
LTCUA(I)=TCUL
N
RTCUA(I) = 0
Y
RTCUA(I)=TCUR
N
BTCUA(I) = 0
Y
BTCUA(I)=TCUTB
N
STOPA = 0
Y
STOPA(I)=STOPN
N
V



W
GREENA = 1.0
Y
N
NS←1
NS:NSMAX
NS←NS+1
>
R
≤
STABLE(NS,3) =IFIX(FLOAT (N5,3)*GREENA +.499)

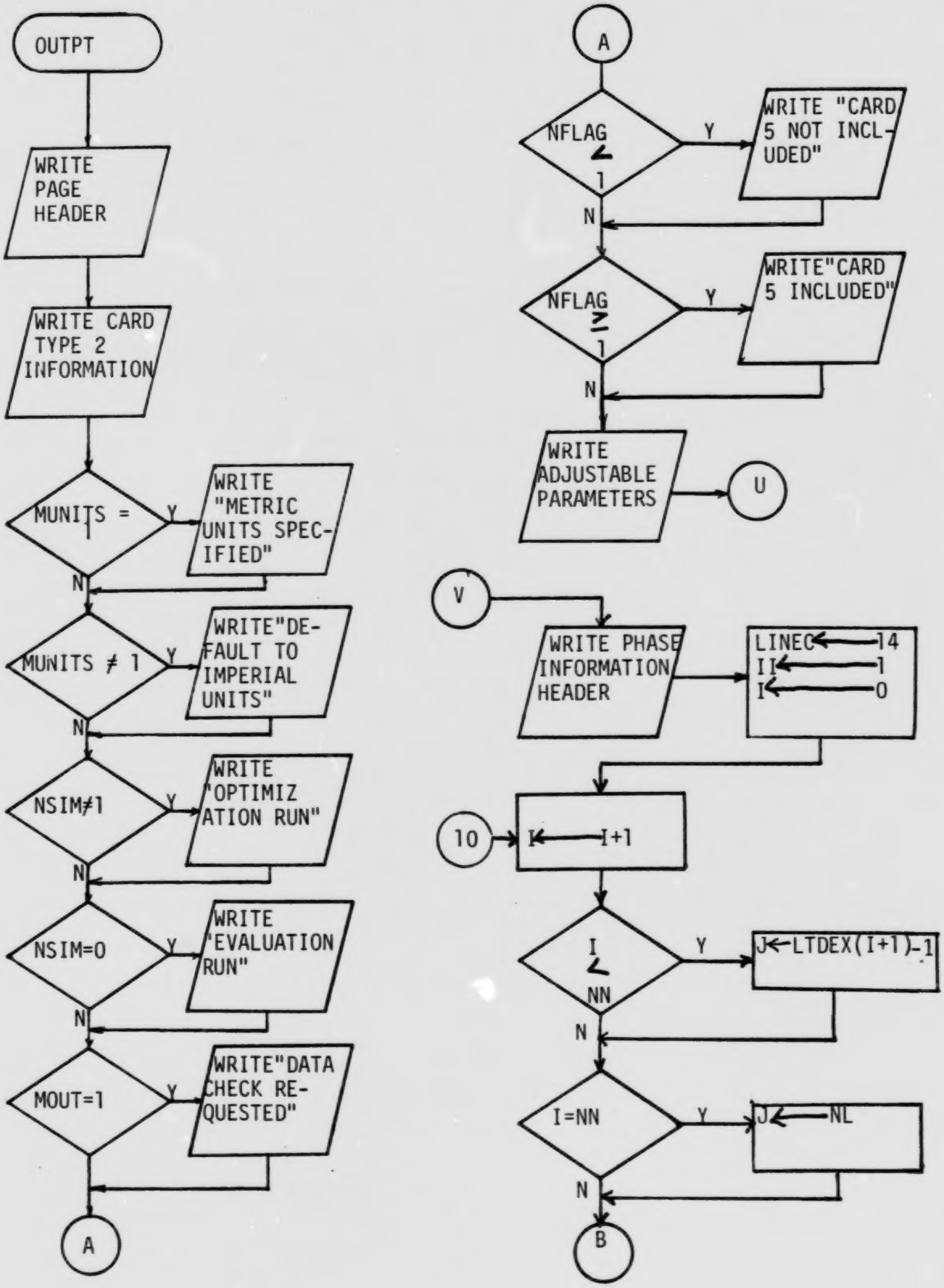

R
I ⟵ 0
120
I=I+1
ADJUST VOLUMES BY 'VOLUMA'
IYS(I)=VOLUME(I)
V=FLOAT(VOLUME(I))
DETERMINE
EQUIVALENT
PCU
VOLUME(I)
NC1,NC2,NC3,
NC4 ⟵ 0
J ⟵ 0
125
J ⟵ J+1
K ⟵ 0
130
K ⟵ K+1
ISOURCE(I,K)I
=
ILINKID(J)I
Y
N
K=1
J
<
2
N
LTYPE(J)
≠
1
Y
Y
N
SOURCE(I,1) ⟵ J
NC1 ⟵ 1
K=2
LTYPE(J)
≠
1
N
SOURCE(I,2) ⟵ J
NC2 ⟵ 1
Y
K=3
LTYPE(J)
≠
1
SOURCE(I,3) ⟵ J
NC3 ⟵ 1
Y
K=4
J
<
2
SOURCE(I,5)
=1 & LTYPE(J,1)
≠ 1
Y
N
SOURCE(I,5)
≠1 & LTYPE(J)
≠ 1
N
SOURCE(I,4) J
NC4 ⟵ 1
Y
130
Y
K
<
4
N
S

INPT

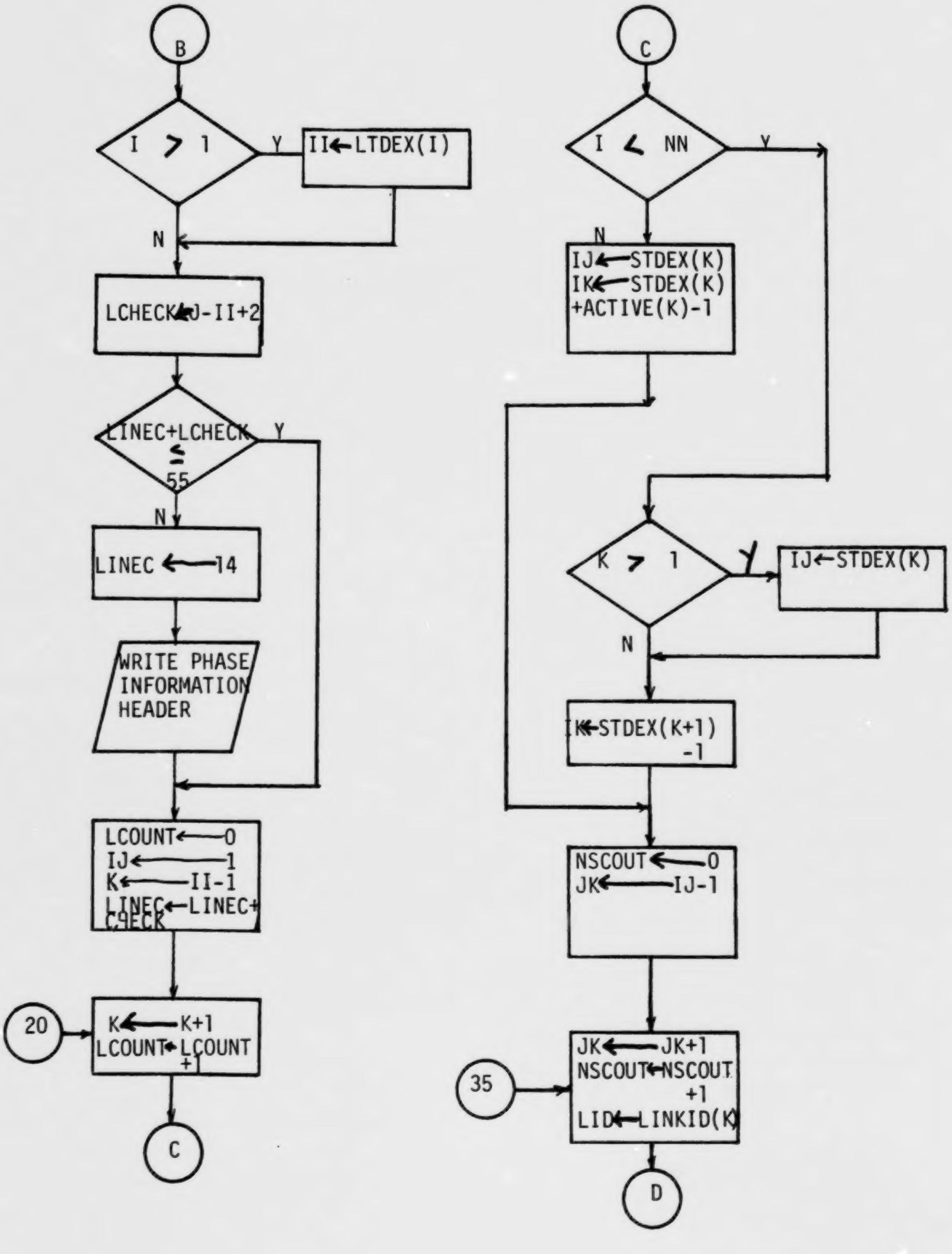


S
J ≮ NL
Y
N
125
SOURCE(I,1)←0
NC1 ≮ 1
SOURCE(I,2)←0
NC2 ≮ 1
SOURCE(I,3)←0
NC3 ≮ 1
SOURCE(I,4)←0
NC4 ≮ 1
I ≮ NL
120
NSIM ≠ 1
RETURN
READ CARD TYPE 6
T
T
170
I=1
I:NN
I=I+1
>
≤
RETURN
READ EXISTING TIMING INFORMATION
JJ←I-1
CARD≠6 AND I ≤ NN
ERROR (18)
205
J=1
J:NN
J=J+1
ERROR(19)
NODE ≠ NNOM(J)
205
NSPITS(J,K)=IK
K = 1,6
NOFFS(J)=IOF
170

SUBROUTINE OUTPT

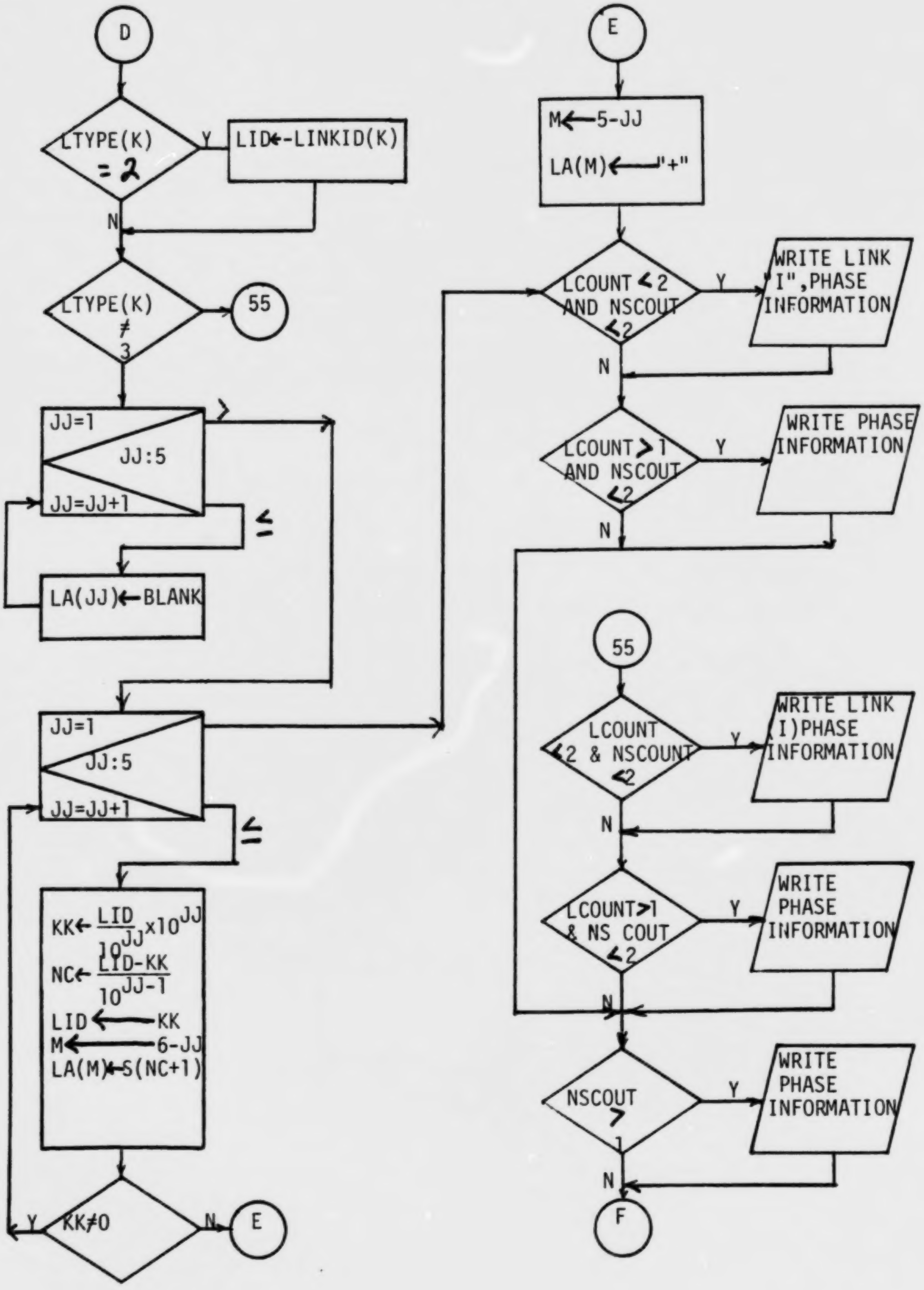

OUTPT
WRITE PAGE HEADER
WRITE CARD TYPE 2 INFORMATION
MUNITS = 1
Y
WRITE "METRIC UNITS SPECIFIED"
N
MUNITS ≠ 1
Y
WRITE "DEFAULT TO IMPERIAL UNITS"
N
NSIM≠1
Y
WRITE "OPTIMIZATION RUN"
N
NSIM=0
Y
WRITE "EVALUATION RUN"
N
MOUT=1
Y
WRITE "DATA CHECK REQUESTED"
A
A
NFLAG < 1
Y
WRITE "CARD 5 NOT INCLUDED"
N
NFLAG ≥ 1
Y
WRITE "CARD 5 INCLUDED"
N
WRITE ADJUSTABLE PARAMETERS
U
V
WRITE PHASE INFORMATION HEADER
LINEC ← 14
II ← 1
I ← 0
10
I ← I+1
I < NN
Y
J ← LTDEX(I+1)-1
N
I=NN
Y
J ← NL
N
B

OUTPT

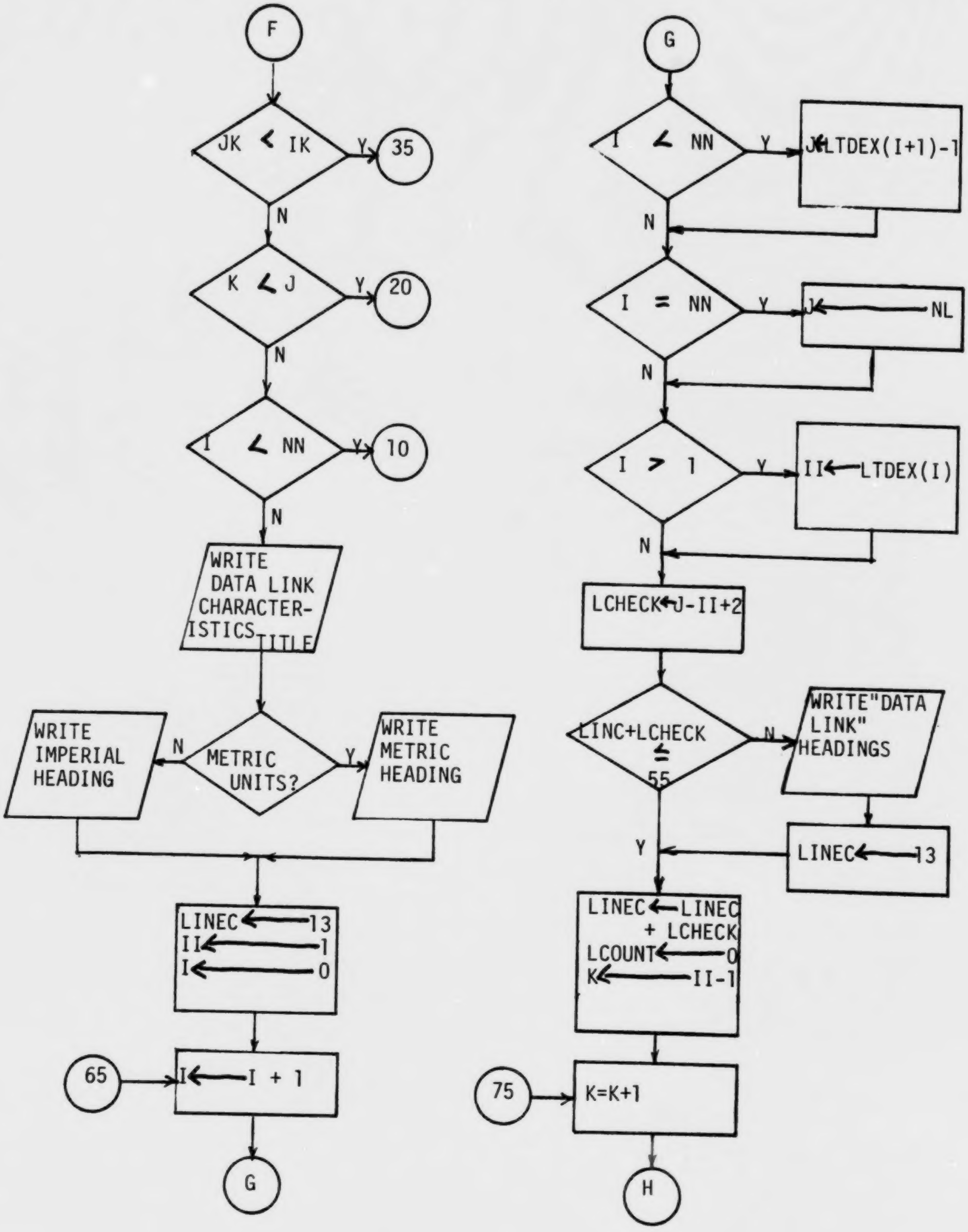


B
I > 1
Y
II←LTDEX(I)
N
LCHECK←IJ-II+2
LINEC+LCHECK ≤ 55
Y
N
LINEC ←14
WRITE PHASE INFORMATION HEADER
LCOUNT←0
IJ←1
K←II-1
LINEC←LINEC+LCHECK
20
K←K+1
LCOUNT←LCOUNT +1
C
C
I < NN
Y
N
IJ←STDEX(K)
IK←STDEX(K) +ACTIVE(K)-1
K > 1
Y
IJ←STDEX(K)
N
IK←STDEX(K+1) -1
NSCOUT←0
JK←IJ-1
35
JK←JK+1
NSCOUT←NSCOUT +1
LID←LINKID(K)
D

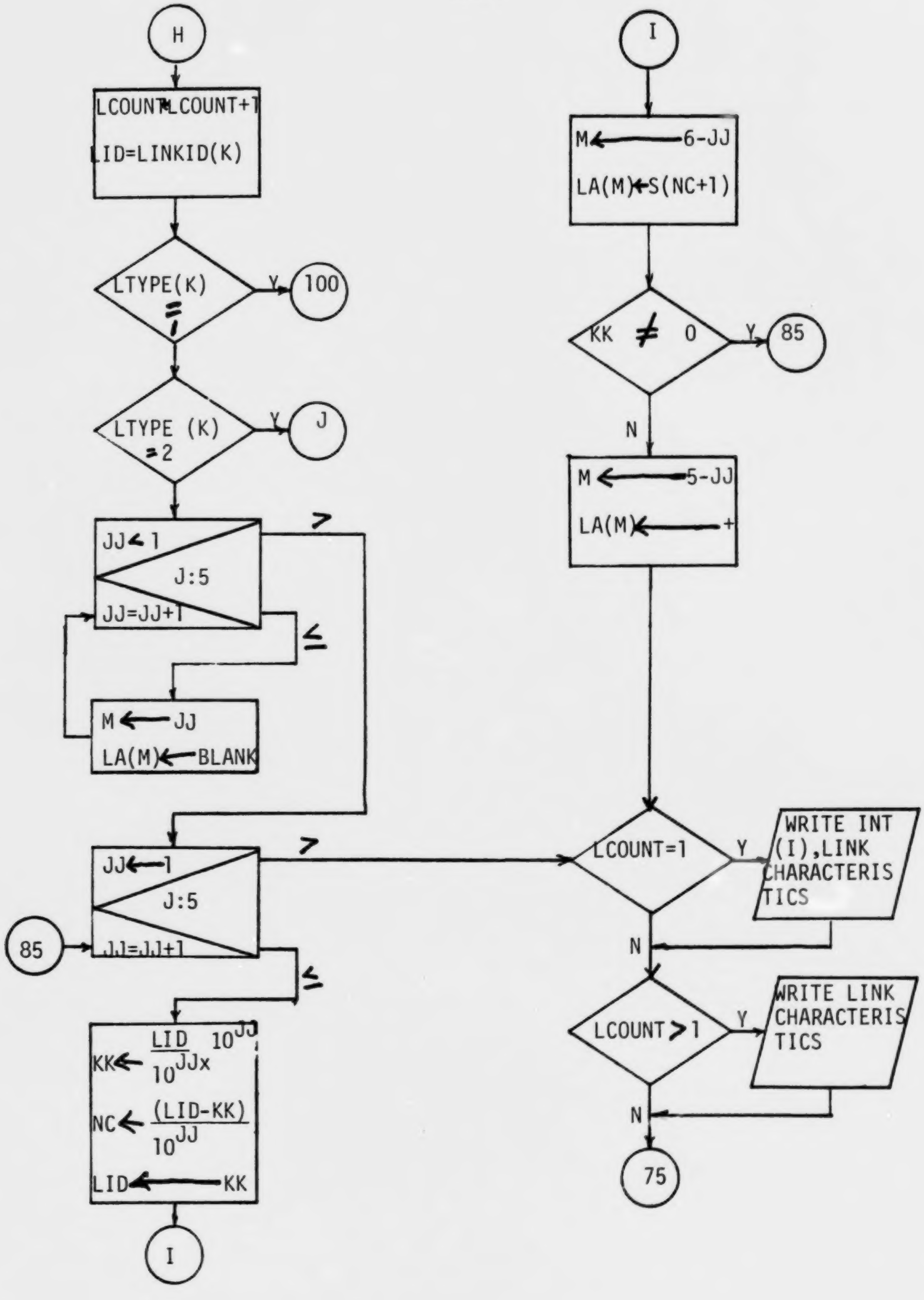
OUTPT


D
LTYPE(K) = 2
Y
LID←-LINKID(K)
N
LTYPE(K) ≠ 3
55
JJ=1
JJ:5
JJ=JJ+1
>
≤
LA(JJ)←BLANK
JJ=1
JJ:5
JJ=JJ+1
≤
KK← LID/10^JJ x10^JJ
NC← LID-KK/10^JJ-1
LID ←KK
M←6-JJ
LA(M)←S(NC+1)
Y
KK≠0
N
E
E
M←5-JJ
LA(M)←"+"
LCOUNT < 2 AND NSCOUT < 2
Y
WRITE LINK "I",PHASE INFORMATION
N
LCOUNT > 1 AND NSCOUT < 2
Y
WRITE PHASE INFORMATION
N
55
LCOUNT < 2 & NSCOUNT < 2
Y
WRITE LINK (I)PHASE INFORMATION
N
LCOUNT>1 & NS COUT < 2
Y
WRITE PHASE INFORMATION
N
NSCOUT > 1
Y
WRITE PHASE INFORMATION
N
F

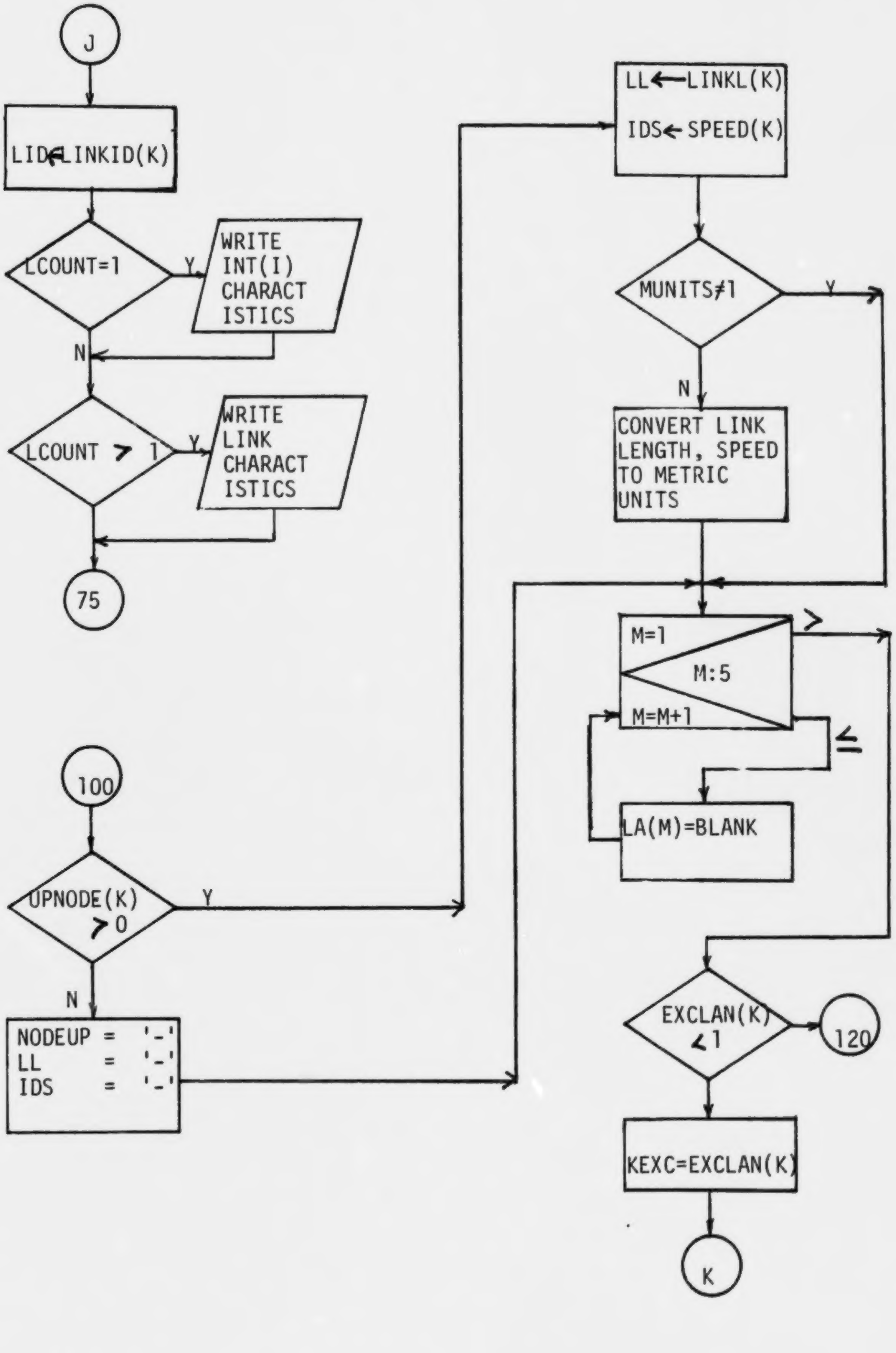
OUTPT


F
JK < IK
Y
35
N
K < J
Y
20
N
I < NN
Y
10
N
WRITE DATA LINK CHARACTER-ISTICS TITLE
METRIC UNITS?
N
WRITE IMPERIAL HEADING
Y
WRITE METRIC HEADING
LINEC ← 13
II ← 1
I ← 0
65
I ← I + 1
G
G
I < NN
Y
J ← LTDEX(I+1)-1
N
I = NN
Y
J ← NL
N
I > 1
Y
II ← LTDEX(I)
N
LCHECK ← J-II+2
LINC+LCHECK ≤ 55
N
WRITE "DATA LINK" HEADINGS
LINEC ← 13
Y
LINEC ← LINEC + LCHECK
LCOUNT ← 0
K ← II-1
75
K=K+1
H

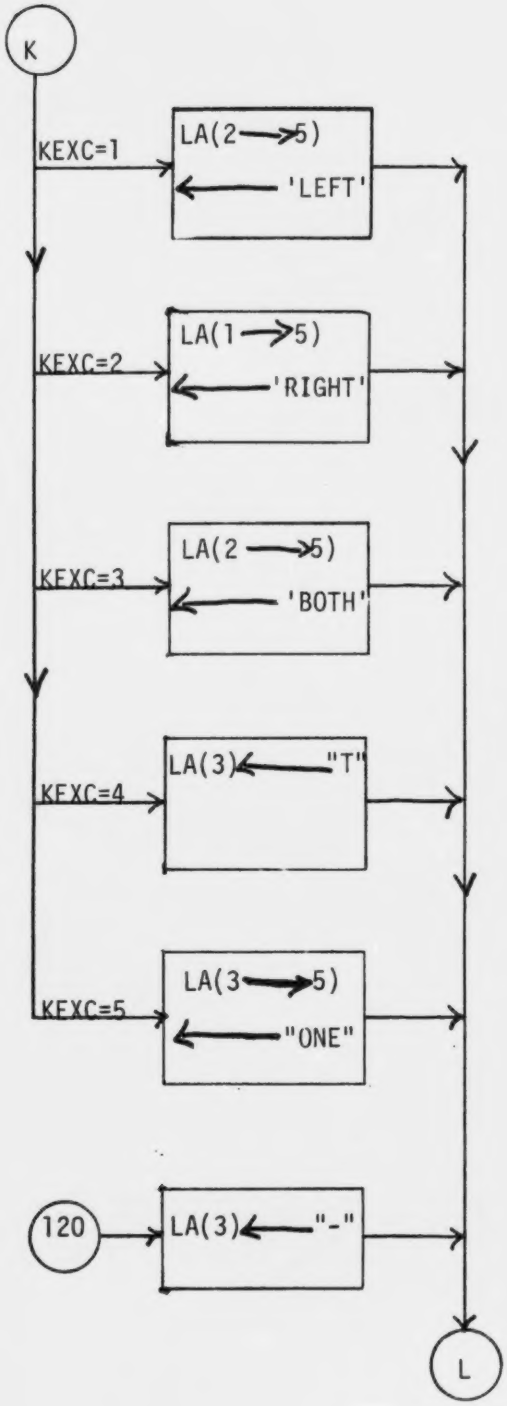
OUTPT

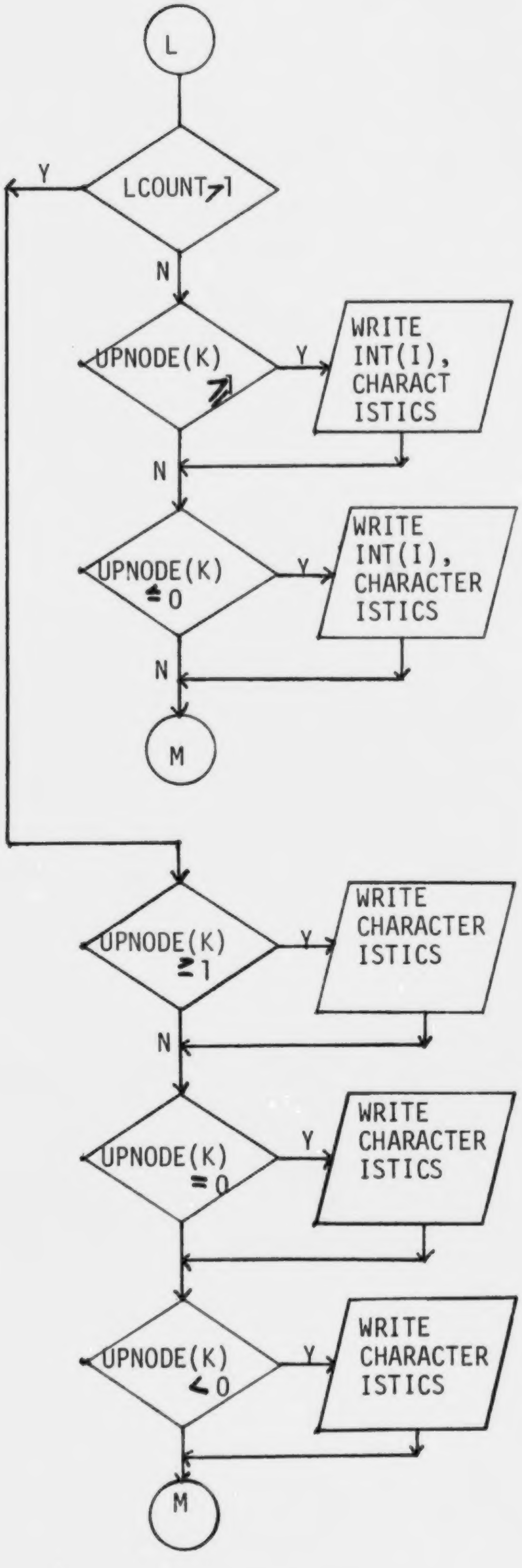

H
LCOUNT←LCOUNT+1
LID=LINKID(K)
LTYPE(K) = 1
Y
100
LTYPE (K) =2
Y
J
JJ←1
J:5
JJ=JJ+1
>
≤
M ← JJ
LA(M) ← BLANK
JJ←1
J:5
85
JJ=JJ+1
>
≤
KK← $\frac{LID}{10^{JJ}}$x 10^{JJ}
NC← $\frac{(LID-KK)}{10^{JJ}}$
LID← KK
I
I
M ← 6-JJ
LA(M)←S(NC+1)
KK ≠ 0
Y
85
N
M ← 5-JJ
LA(M) ← +
LCOUNT=1
Y
WRITE INT (I),LINK CHARACTERISTICS
N
LCOUNT > 1
Y
WRITE LINK CHARACTERISTICS
N
75

OUTPT

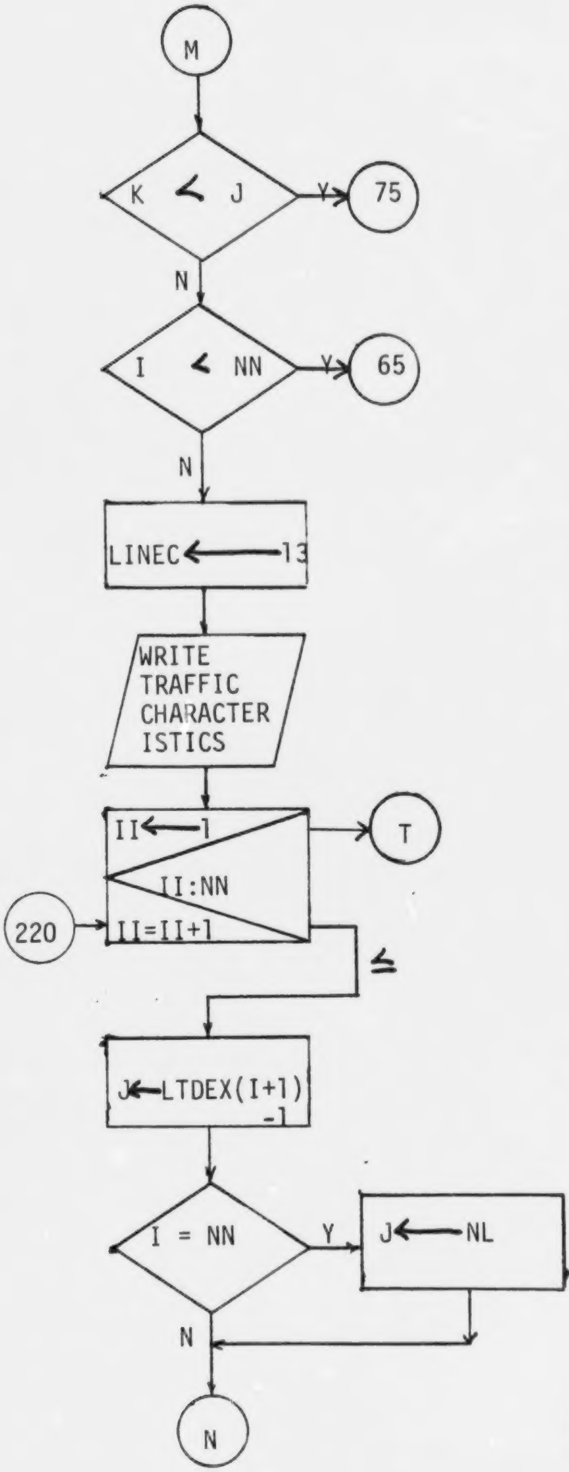

J
LID←LINKID(K)
LCOUNT=1
Y
WRITE INT(I) CHARACT ISTICS
N
LCOUNT > 1
Y
WRITE LINK CHARACT ISTICS
75
100
UPNODE(K) > 0
Y
N
NODEUP = '-'
LL = '-'
IDS = '-'
LL←LINKL(K)
IDS←SPEED(K)
MUNITS≠1
Y
N
CONVERT LINK LENGTH, SPEED TO METRIC UNITS
M=1
M:5
M=M+1
>
≤
LA(M)=BLANK
EXCLAN(K) < 1
120
KEXC=EXCLAN(K)
K

OUTPT

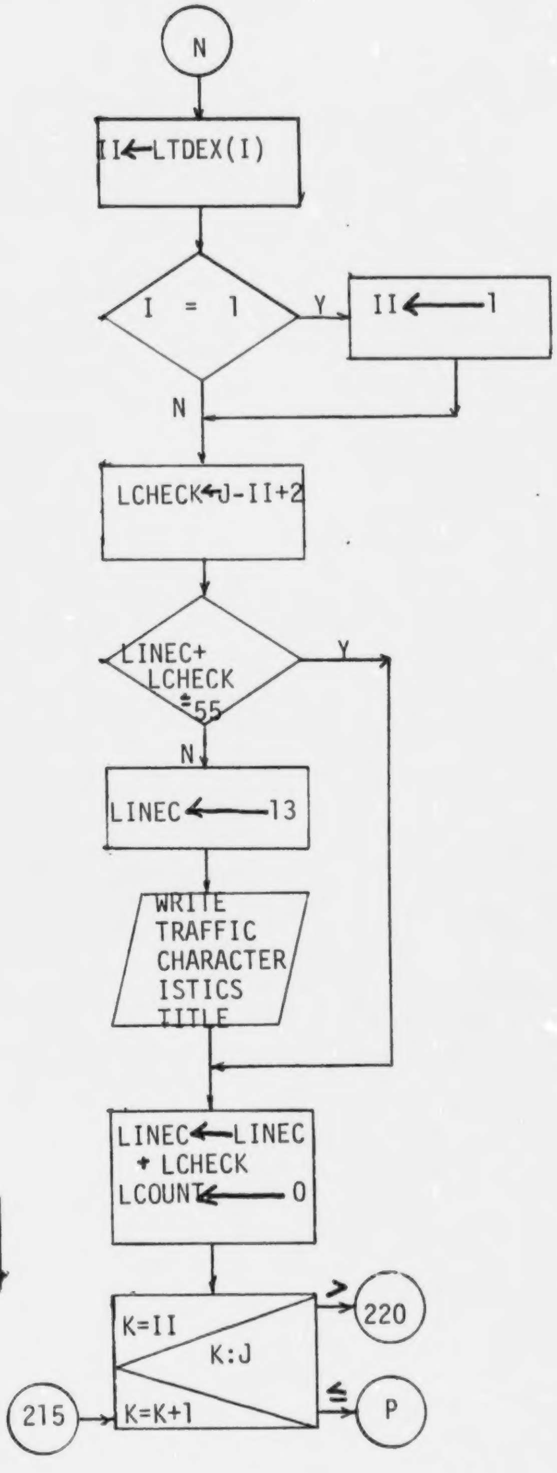

K
KEXC=1
LA(2→5)
← 'LEFT'
KEXC=2
LA(1→5)
← 'RIGHT'
KEXC=3
LA(2→5)
← 'BOTH'
KEXC=4
LA(3) ← "T"
KEXC=5
LA(3→5)
← "ONE"
120
LA(3) ← "-"
L


L
LCOUNT > 1
Y
N
UPNODE(K) ≥ 1
Y
WRITE INT(I), CHARACT ISTICS
N
UPNODE(K) ≤ 0
Y
WRITE INT(I), CHARACTER ISTICS
N
M
UPNODE(K) ≥ 1
Y
WRITE CHARACTER ISTICS
N
UPNODE(K) = 0
Y
WRITE CHARACTER ISTICS
UPNODE(K) < 0
Y
WRITE CHARACTER ISTICS
M

OUTPT

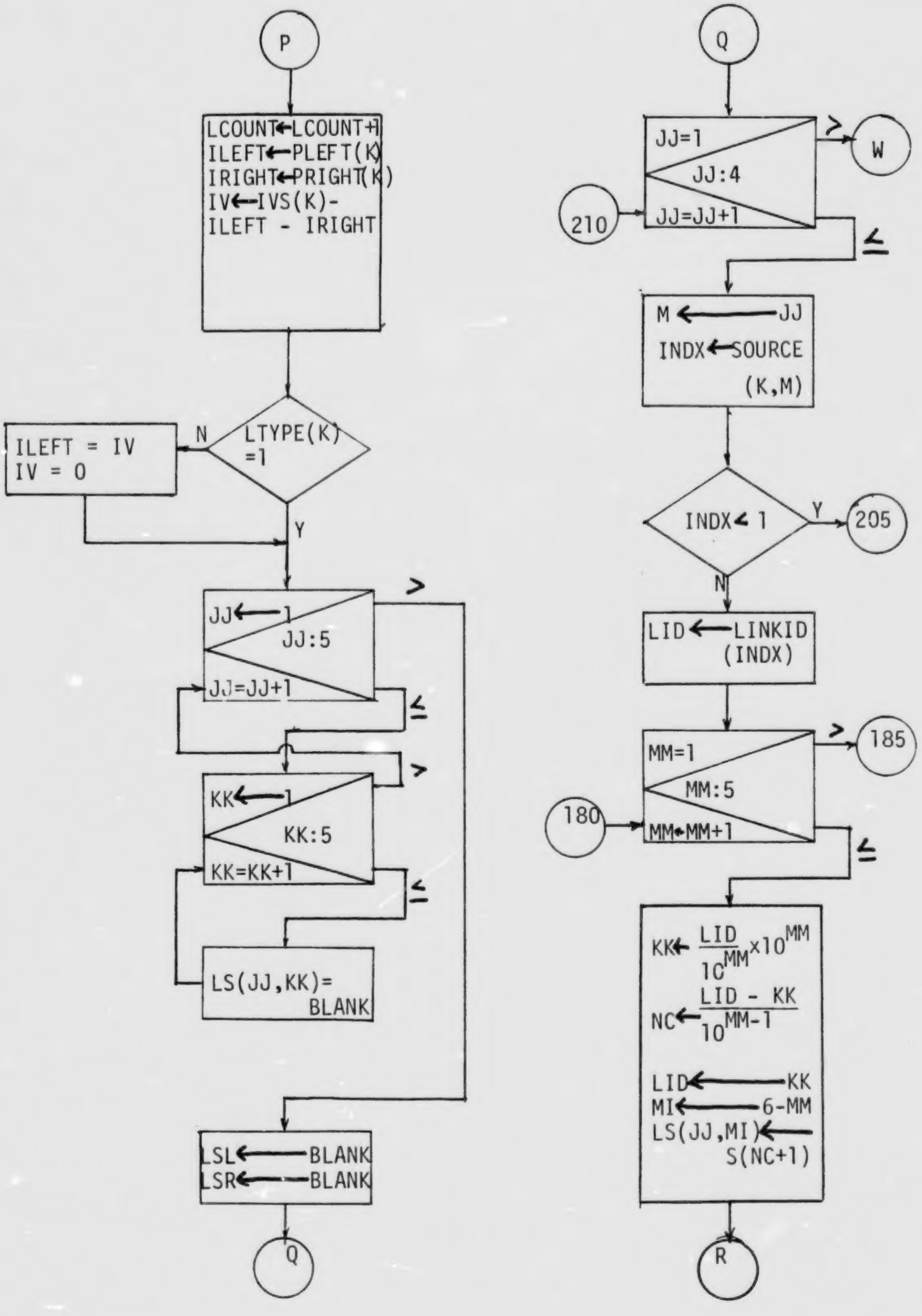


M
K < J
Y
75
N
I < NN
Y
65
N
LINEC ← 13
WRITE TRAFFIC CHARACTER ISTICS
II ← 1
II:NN
II=II+1
220
T
≤
J ← LTDEX(I+1) -1
I = NN
Y
J ← NL
N
N

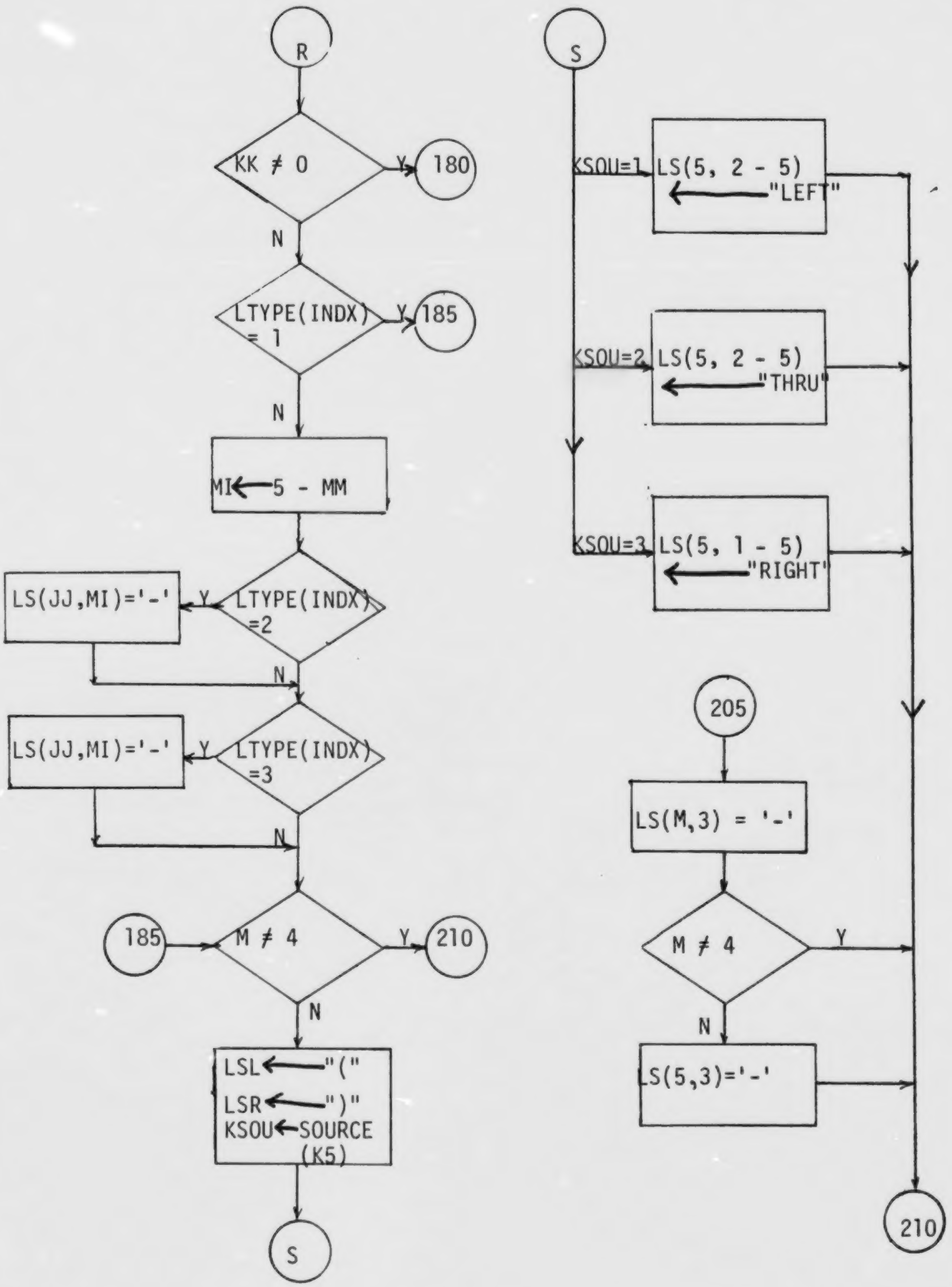


N
II ← LTDEX(I)
I = 1
Y
II ← 1
N
LCHECK ← J-II+2
LINEC+ LCHECK ≑55
Y
N
LINEC ← 13
WRITE TRAFFIC CHARACTER ISTICS TITLE
LINEC ← LINEC + LCHECK
LCOUNT ← 0
K=II
K:J
K=K+1
>
220
≤
P
215

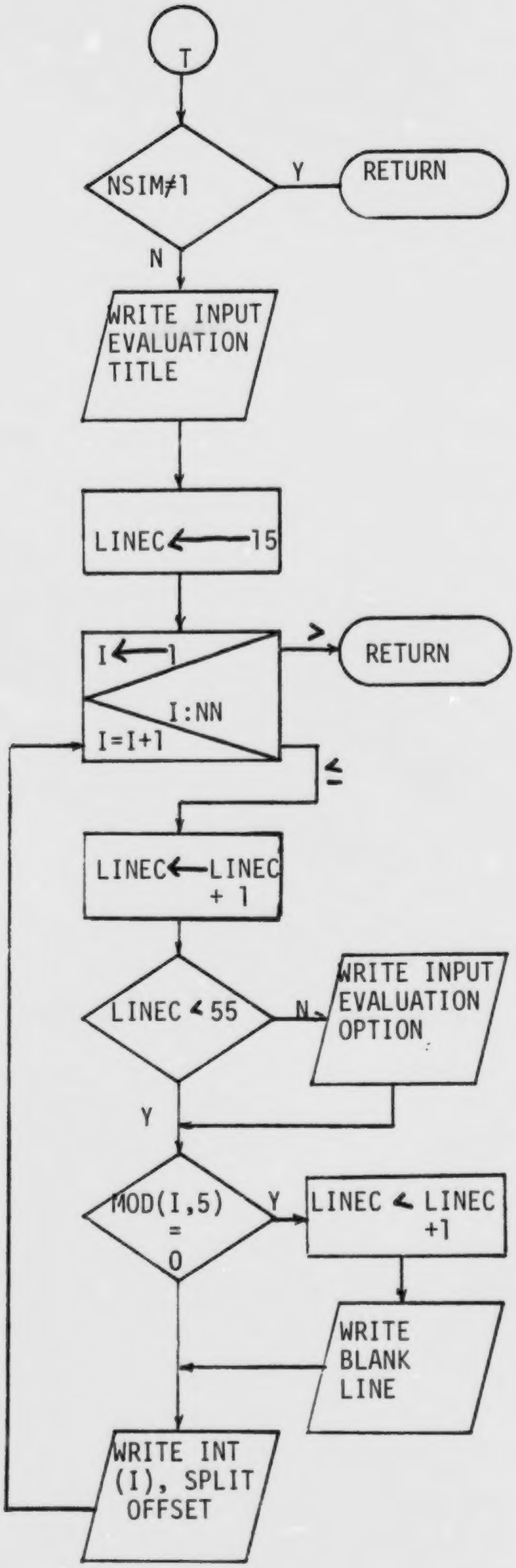
OUTPT

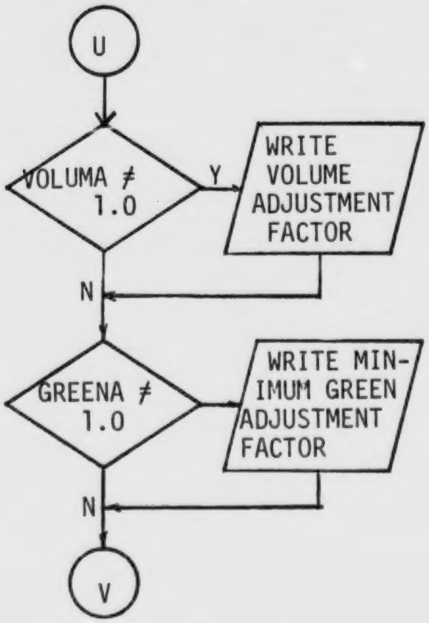

P
LCOUNT←LCOUNT+1
ILEFT←PLEFT(K)
IRIGHT←PRIGHT(K)
IV←IVS(K)-
ILEFT - IRIGHT
LTYPE(K)
=1
N
ILEFT = IV
IV = 0
Y
JJ←1
JJ:5
JJ=JJ+1
>
≤
KK←1
KK:5
KK=KK+1
>
≤
LS(JJ,KK)=
BLANK
LSL←BLANK
LSR←BLANK
Q
Q
JJ=1
JJ:4
JJ=JJ+1
>
W
210
≤
M←JJ
INDX←SOURCE
(K,M)
INDX≤1
Y
205
N
LID←LINKID
(INDX)
MM=1
MM:5
MM←MM+1
>
185
180
≤
KK← LID/10^MM ×10^MM
NC← (LID - KK)/10^(MM-1)
LID←KK
MI←6-MM
LS(JJ,MI)←
S(NC+1)
R

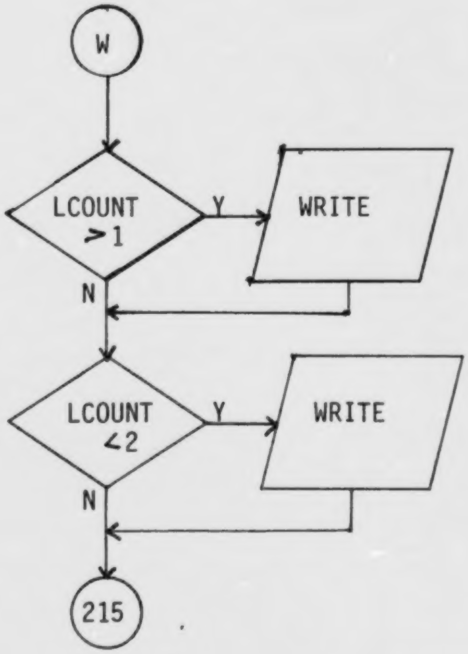
OUTPT


R
KK ≠ 0
Y
180
N
LTYPE(INDX) = 1
Y
185
N
MI ← 5 - MM
LS(JJ,MI)='-'
Y
LTYPE(INDX) =2
N
LS(JJ,MI)='-'
Y
LTYPE(INDX) =3
N
185
M ≠ 4
Y
210
N
LSL ← "("
LSR ← ")"
KSOU ← SOURCE (K5)
S
S
KSOU=1
LS(5, 2 - 5) ← "LEFT"
KSOU=2
LS(5, 2 - 5) ← "THRU"
KSOU=3
LS(5, 1 - 5) ← "RIGHT"
205
LS(M,3) = '-'
M ≠ 4
Y
N
LS(5,3)='-'
210

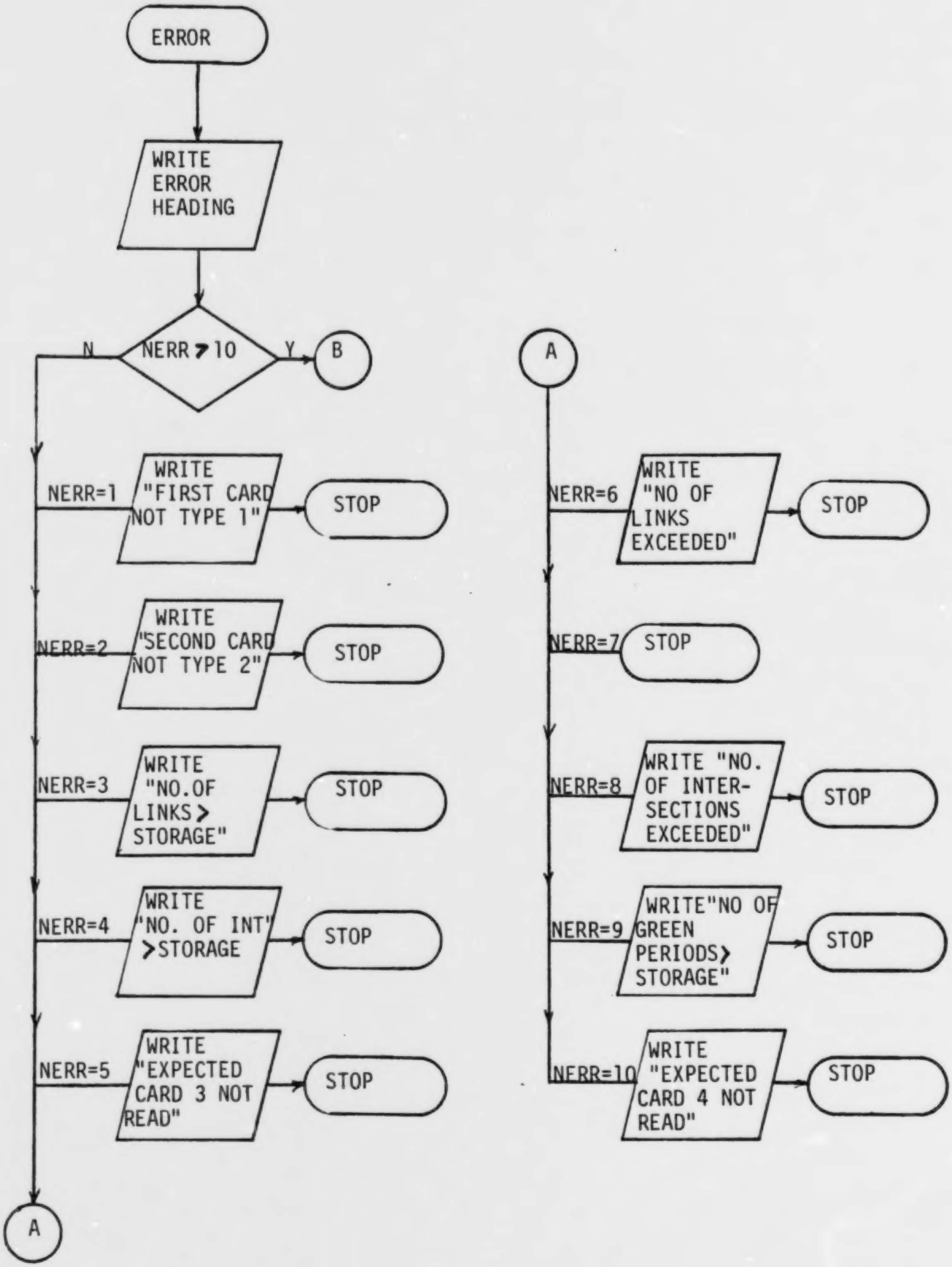
OUTPT


T
NSIM≠1
Y
RETURN
N
WRITE INPUT EVALUATION TITLE
LINEC ← 15
I ← 1
I:NN
I=I+1
>
RETURN
≤
LINEC ← LINEC + 1
LINEC < 55
N
WRITE INPUT EVALUATION OPTION
Y
MOD(I,5) = 0
Y
LINEC ← LINEC +1
WRITE BLANK LINE
WRITE INT (I), SPLIT OFFSET


U
VOLUMA ≠ 1.0
Y
WRITE VOLUME ADJUSTMENT FACTOR
N
GREENA ≠ 1.0
WRITE MINIMUM GREEN ADJUSTMENT FACTOR
N
V

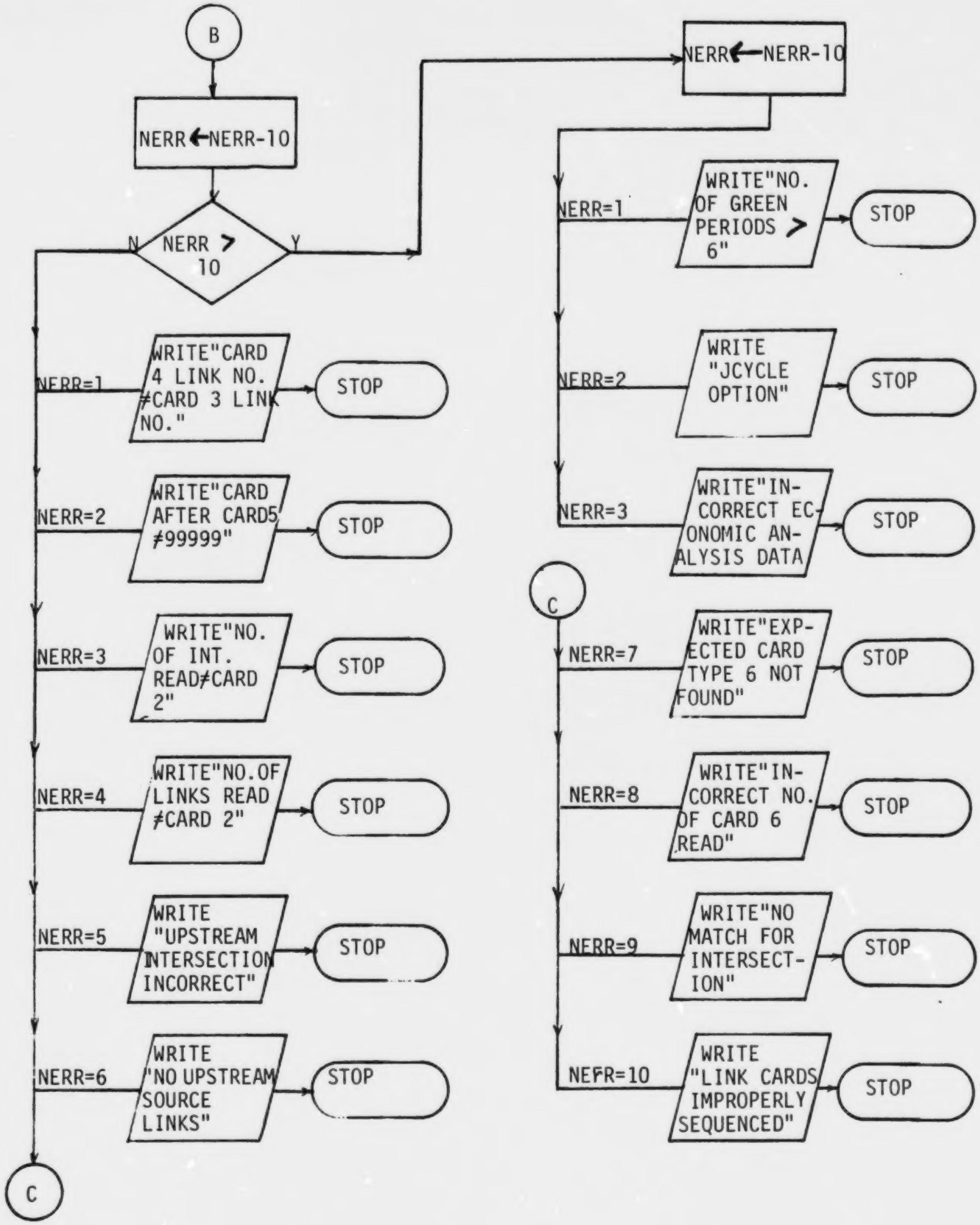

W
LCOUNT > 1
Y
WRITE
N
LCOUNT < 2
Y
WRITE
N
215

SUBROUTINE ERROR

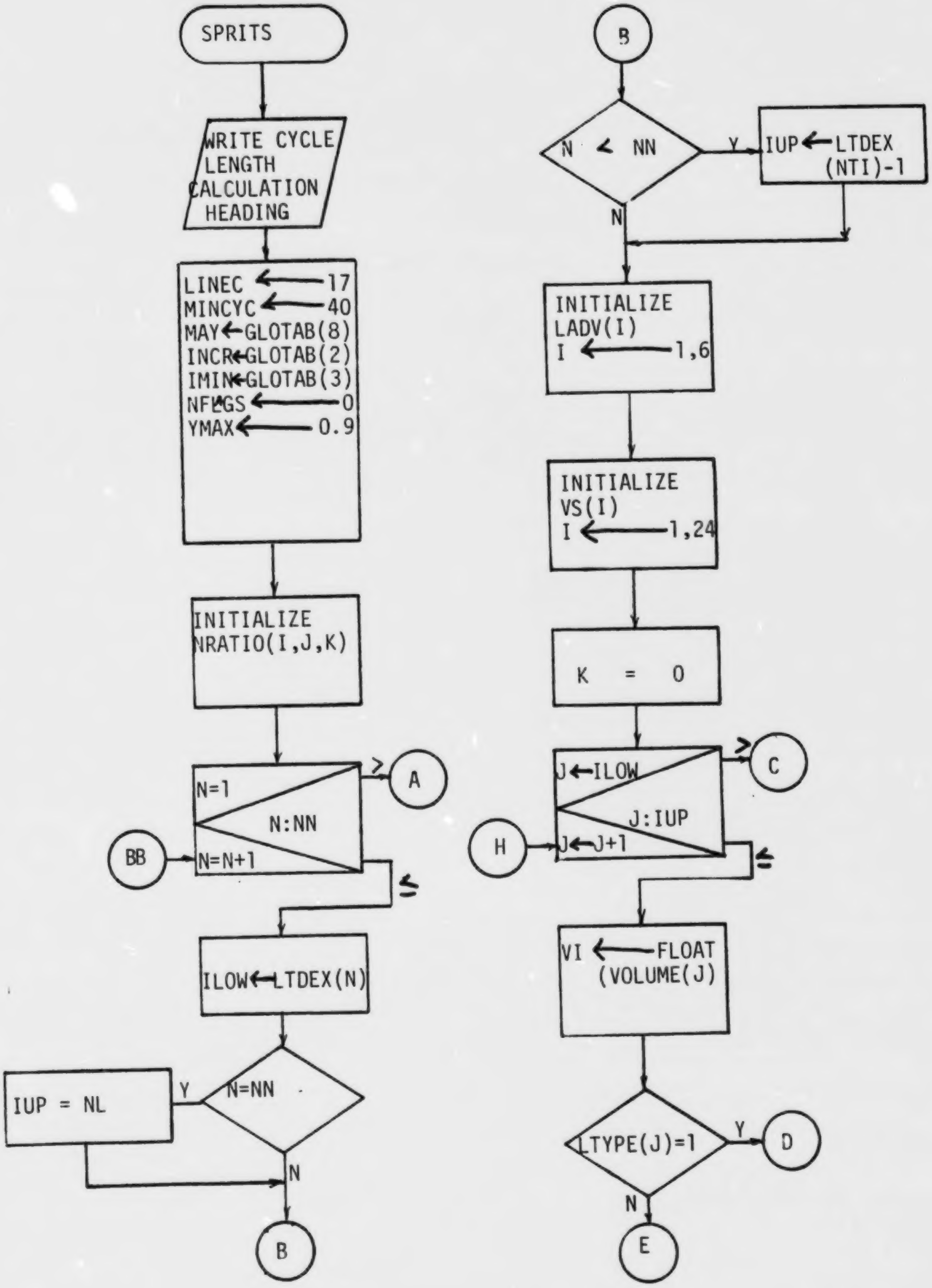


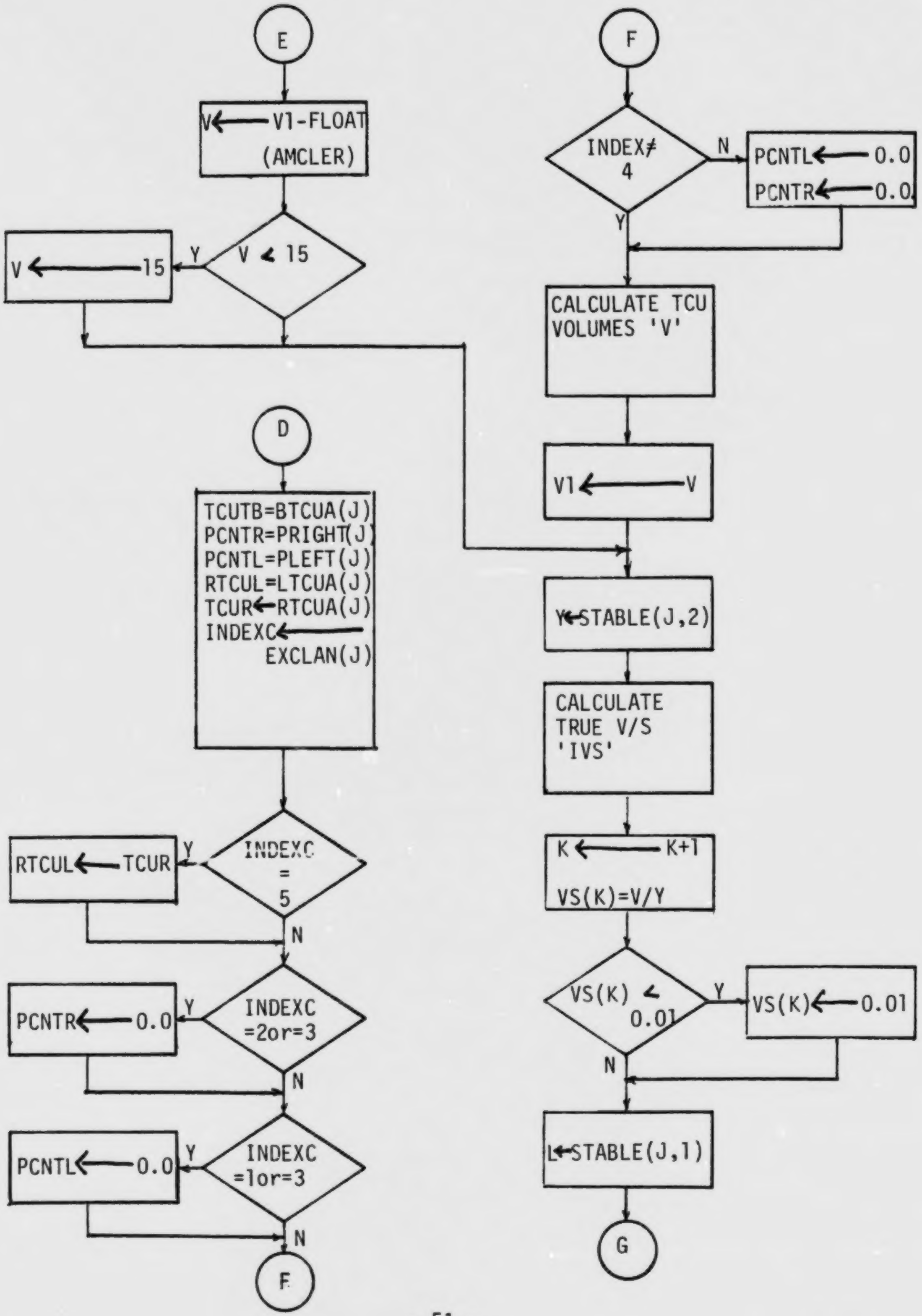
ERROR
WRITE ERROR HEADING
NERR > 10
N
Y
B
NERR=1
WRITE "FIRST CARD NOT TYPE 1"
STOP
NERR=2
WRITE "SECOND CARD NOT TYPE 2"
STOP
NERR=3
WRITE "NO.OF LINKS > STORAGE"
STOP
NERR=4
WRITE "NO. OF INT" >STORAGE
STOP
NERR=5
WRITE "EXPECTED CARD 3 NOT READ"
STOP
A
A
NERR=6
WRITE "NO OF LINKS EXCEEDED"
STOP
NERR=7
STOP
NERR=8
WRITE "NO. OF INTER-SECTIONS EXCEEDED"
STOP
NERR=9
WRITE"NO OF GREEN PERIODS> STORAGE"
STOP
NERR=10
WRITE "EXPECTED CARD 4 NOT READ"
STOP

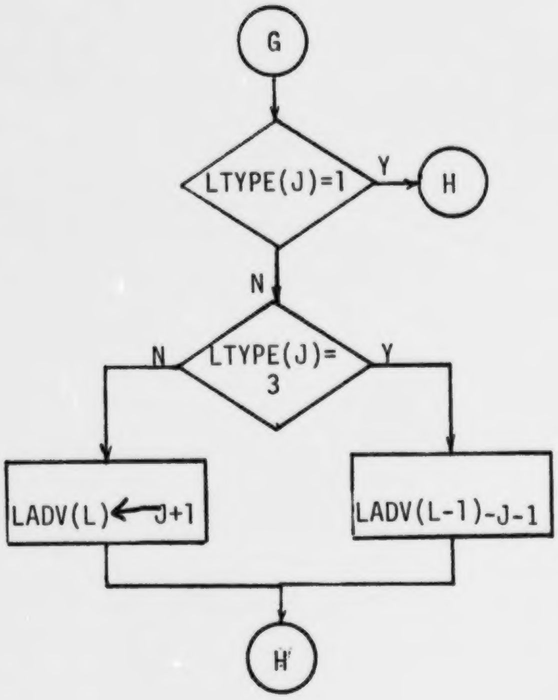
ERROR

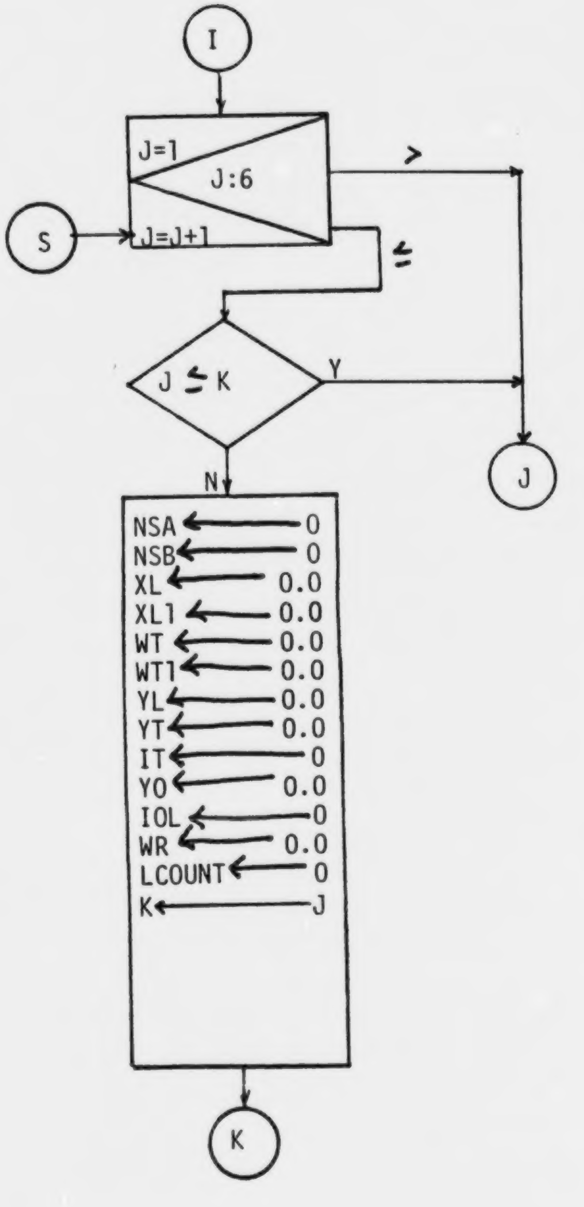

B
NERR←NERR-10
NERR > 10
N
Y
NERR=1
WRITE"CARD 4 LINK NO. ≠CARD 3 LINK NO."
STOP
NERR=2
WRITE"CARD AFTER CARD5 ≠99999"
STOP
NERR=3
WRITE"NO. OF INT. READ≠CARD 2"
STOP
NERR=4
WRITE"NO.OF LINKS READ ≠CARD 2"
STOP
NERR=5
WRITE "UPSTREAM INTERSECTION INCORRECT"
STOP
NERR=6
WRITE "NO UPSTREAM SOURCE LINKS"
STOP
C
NERR←NERR-10
NERR=1
WRITE"NO. OF GREEN PERIODS > 6"
STOP
NERR=2
WRITE "JCYCLE OPTION"
STOP
NERR=3
WRITE"INCORRECT ECONOMIC ANALYSIS DATA
STOP
C
NERR=7
WRITE"EXPECTED CARD TYPE 6 NOT FOUND"
STOP
NERR=8
WRITE"INCORRECT NO. OF CARD 6 READ"
STOP
NERR=9
WRITE"NO MATCH FOR INTERSECTION"
STOP
NEFR=10
WRITE "LINK CARDS IMPROPERLY SEQUENCED"
STOP

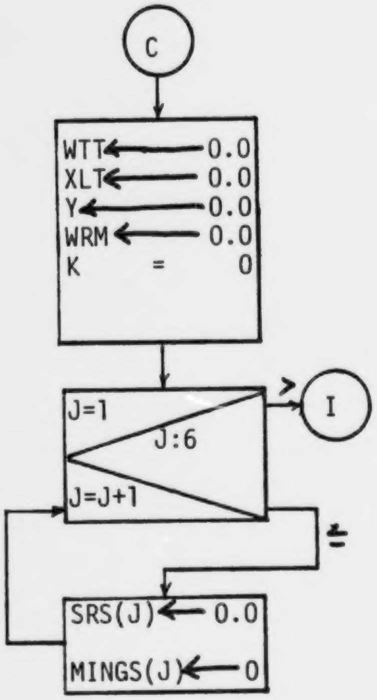
SUBROUTINE SPRITS


SPRITS
WRITE CYCLE LENGTH CALCULATION HEADING
LINEC ← 17
MINCYC ← 40
MAY ← GLOTAB(8)
INCR ← GLOTAB(2)
IMIN ← GLOTAB(3)
NFLGS ← 0
YMAX ← 0.9
INITIALIZE NRATIO(I,J,K)
N=1
N:NN
N=N+1
>
≤
A
BB
ILOW ← LTDEX(N)
N=NN
Y
N
IUP = NL
B
B
N < NN
Y
N
IUP ← LTDEX (NTI)-1
INITIALIZE LADV(I) I ← 1,6
INITIALIZE VS(I) I ← 1,24
K = 0
J ← ILOW
J:IUP
J ← J+1
>
≤
C
H
VI ← FLOAT (VOLUME(J)
LTYPE(J)=1
Y
N
D
E

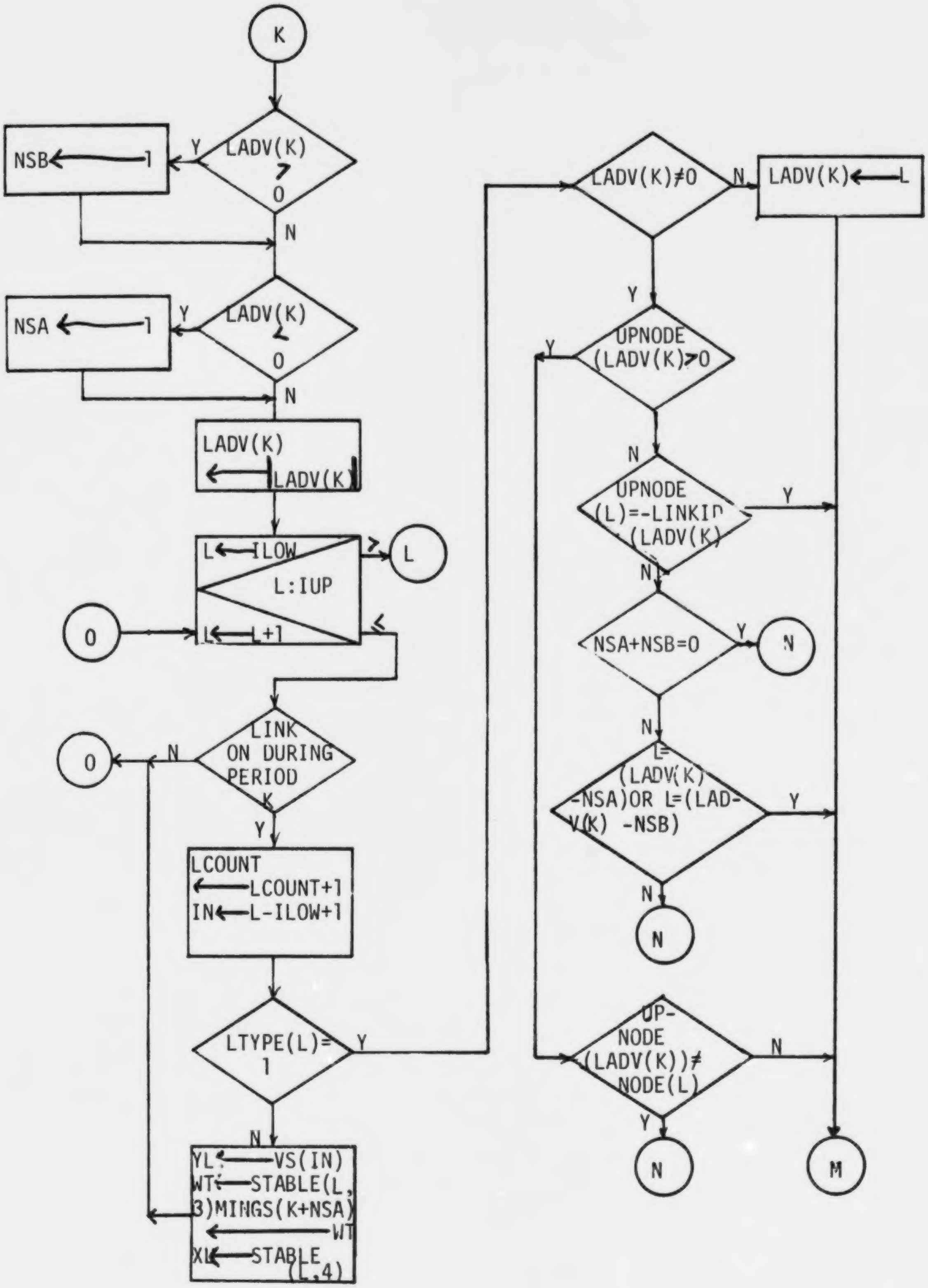

E
V ← V1-FLOAT (AMCLER)
V < 15
Y
V ← 15
D
TCUTB=BTCUA(J)
PCNTR=PRIGHT(J)
PCNTL=PLEFT(J)
RTCUL=LTCUA(J)
TCUR←RTCUA(J)
INDEXC ← EXCLAN(J)
INDEXC = 5
Y
RTCUL ← TCUR
N
INDEXC =2or=3
Y
PCNTR ← 0.0
N
INDEXC =1or=3
Y
PCNTL ← 0.0
N
F
F
INDEX≠ 4
N
PCNTL ← 0.0
PCNTR ← 0.0
Y
CALCULATE TCU VOLUMES 'V'
V1 ← V
Y←STABLE(J,2)
CALCULATE TRUE V/S 'IVS'
K ← K+1
VS(K)=V/Y
VS(K) < 0.01
Y
VS(K) ← 0.01
N
L←STABLE(J,1)
G


G
LTYPE(J)=1
Y
H
N
N
LTYPE(J)= 3
Y
LADV(L)←J+1
LADV(L-1)-J-1
H

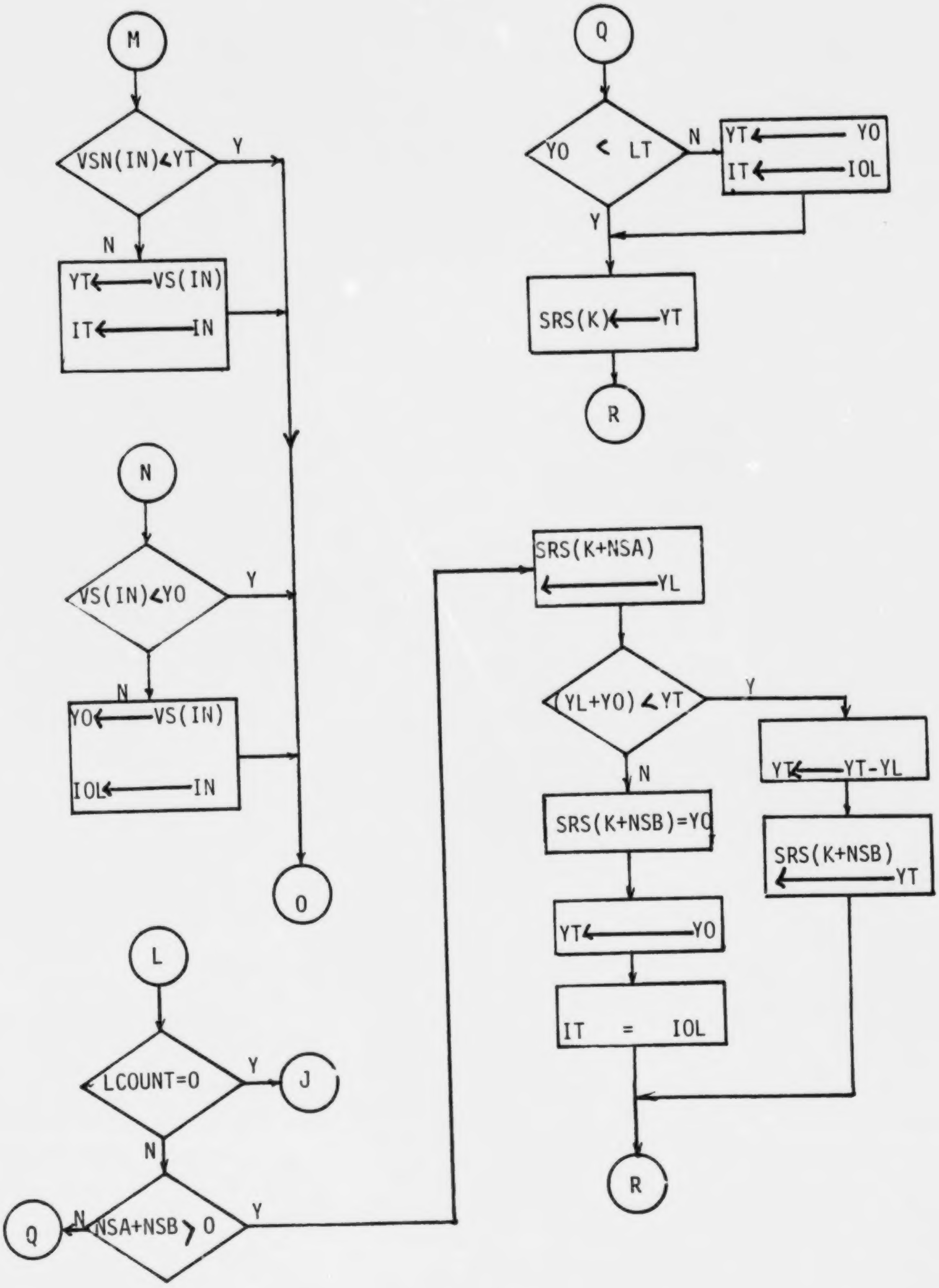

I
J=1
J:6
J=J+1
>
S
≤
J ≤ K
Y
N
J
NSA←0
NSB←0
XL←0.0
XL1←0.0
WT←0.0
WT1←0.0
YL←0.0
YT←0.0
IT←0
YO←0.0
IOL←0
WR←0.0
LCOUNT←0
K←J
K


C
WTT←0.0
XLT←0.0
Y←0.0
WRM←0.0
K = 0
J=1
J:6
J=J+1
>
I
≤
SRS(J)←0.0
MINGS(J)←0

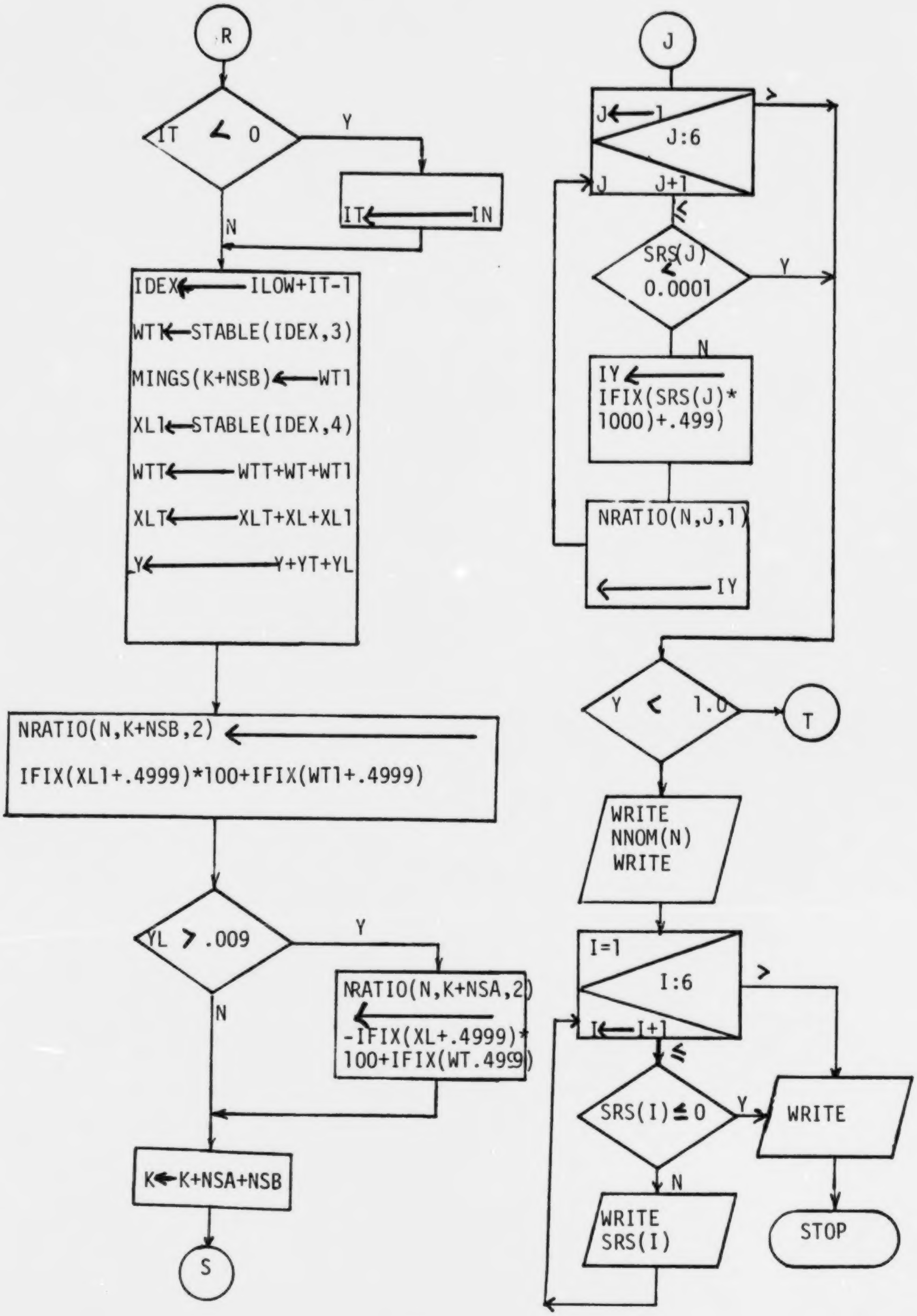
SPRITS


K
LADV(K) > 0
Y
NSB ← 1
N
LADV(K) < 0
Y
NSA ← 1
N
LADV(K) ← LADV(K)
L ← ILOW
L:IUP
L ← L+1
>
L
<
O
LINK ON DURING PERIOD K
N
O
Y
LCOUNT ← LCOUNT+1
IN ← L-ILOW+1
LTYPE(L)= 1
Y
N
YL ← VS(IN)
WT ← STABLE(L,3)
MINGS(K+NSA) ← WT
XL ← STABLE(L,4)
LADV(K)≠0
N
LADV(K) ← L
Y
UPNODE (LADV(K)>0
Y
N
UPNODE (L)=-LINKID (LADV(K)
Y
N
NSA+NSB=0
Y
N
N
L=(LADV(K) -NSA)OR L=(LADV(K) -NSB)
Y
N
N
UPNODE (LADV(K))≠ NODE(L)
N
Y
N
M

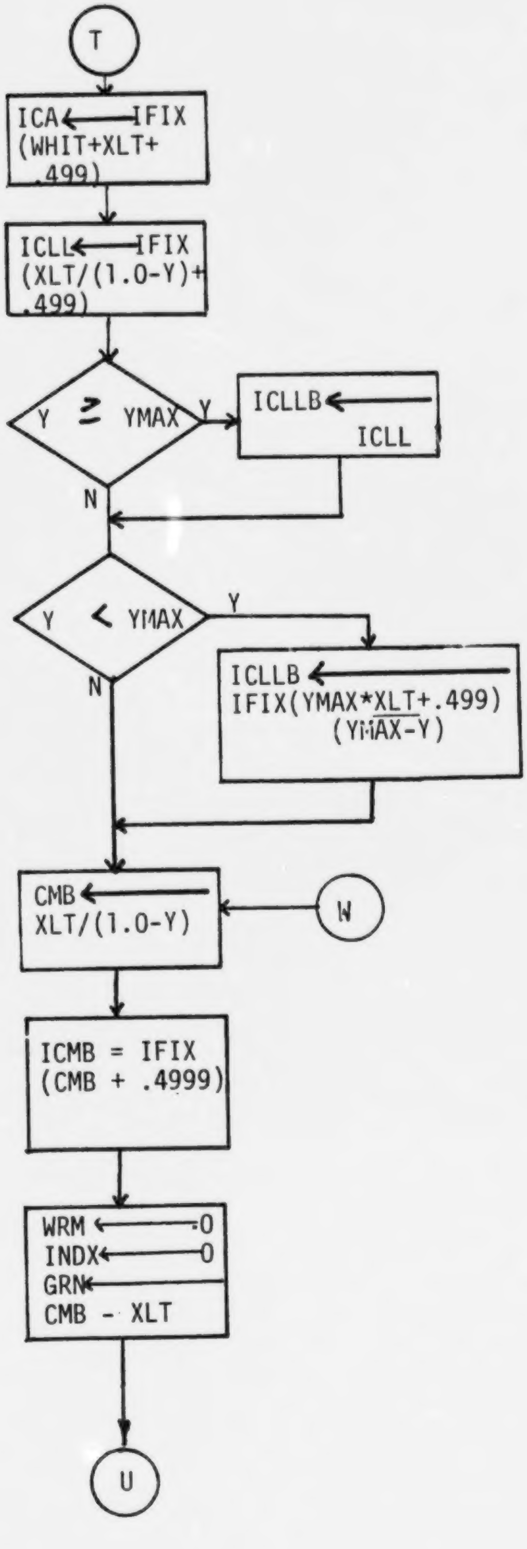
SPRITS

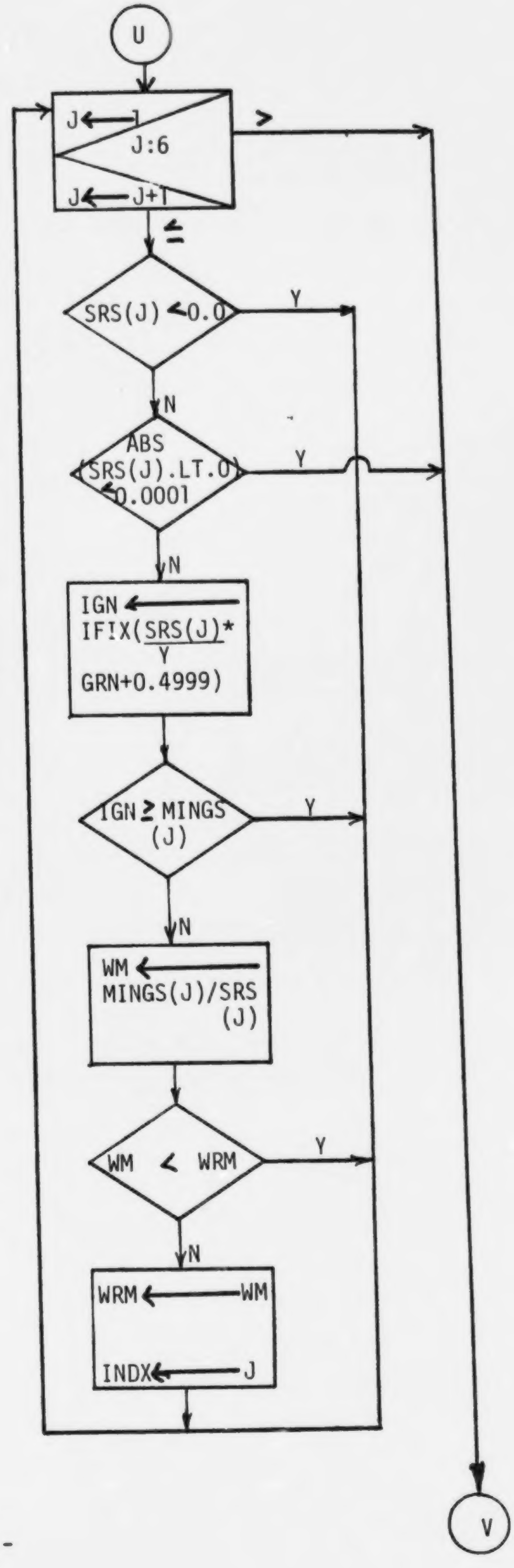

M
VSN(IN)<YT
Y
N
YT ← VS(IN)
IT ← IN
N
VS(IN)<YO
Y
N
YO ← VS(IN)
IOL ← IN
O
L
LCOUNT=0
Y
J
N
NSA+NSB > 0
N
Q
Y
Q
YO < LT
N
YT ← YO
IT ← IOL
Y
SRS(K) ← YT
R
SRS(K+NSA) ← YL
(YL+YO) < YT
Y
YT ← YT-YL
SRS(K+NSB) ← YT
N
SRS(K+NSB)=YO
YT ← YO
IT = IOL
R

SPRITS

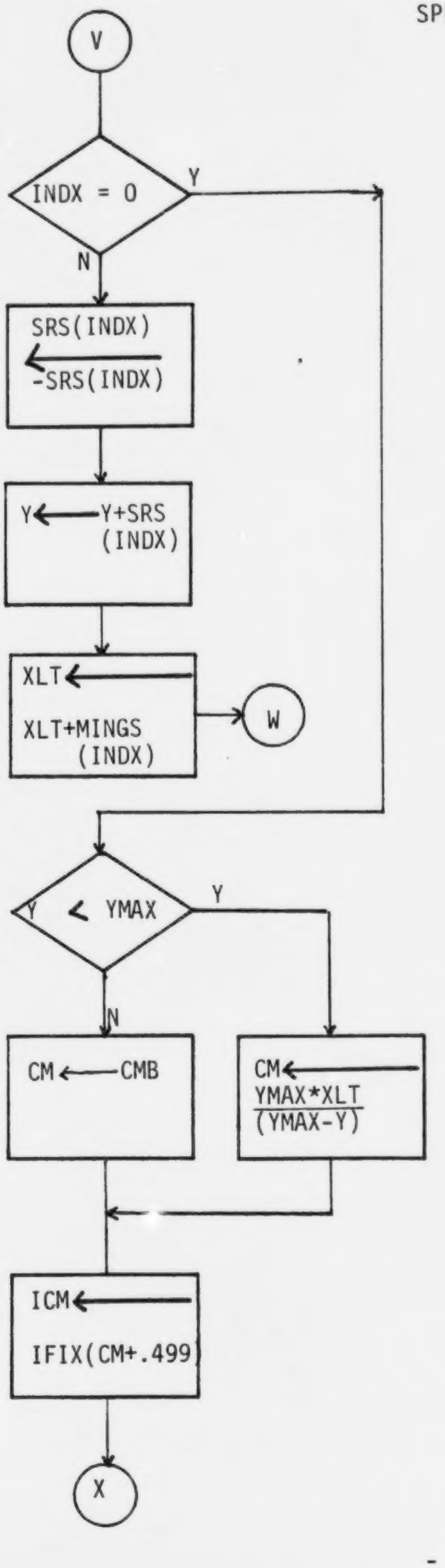

R
IT < 0
Y
IT ← IN
N
IDEX ← ILOW+IT-1
WT1 ← STABLE(IDEX,3)
MINGS(K+NSB) ← WT1
XL1 ← STABLE(IDEX,4)
WTT ← WTT+WT+WT1
XLT ← XLT+XL+XL1
Y ← Y+YT+YL
NRATIO(N,K+NSB,2) ←
IFIX(XL1+.4999)*100+IFIX(WT1+.4999)
YL > .009
Y
NRATIO(N,K+NSA,2)
←
-IFIX(XL+.4999)*
100+IFIX(WT.4999)
N
K ← K+NSA+NSB
S
J
J ← 1
J:6
J
J+1
>
≤
SRS(J)
<
0.0001
Y
N
IY ←
IFIX(SRS(J)*
1000)+.499)
NRATIO(N,J,1)
← IY
Y < 1.0
T
WRITE
NNOM(N)
WRITE
I=1
I:6
I ← I+1
>
≤
SRS(I) ≤ 0
Y
WRITE
N
WRITE
SRS(I)
STOP

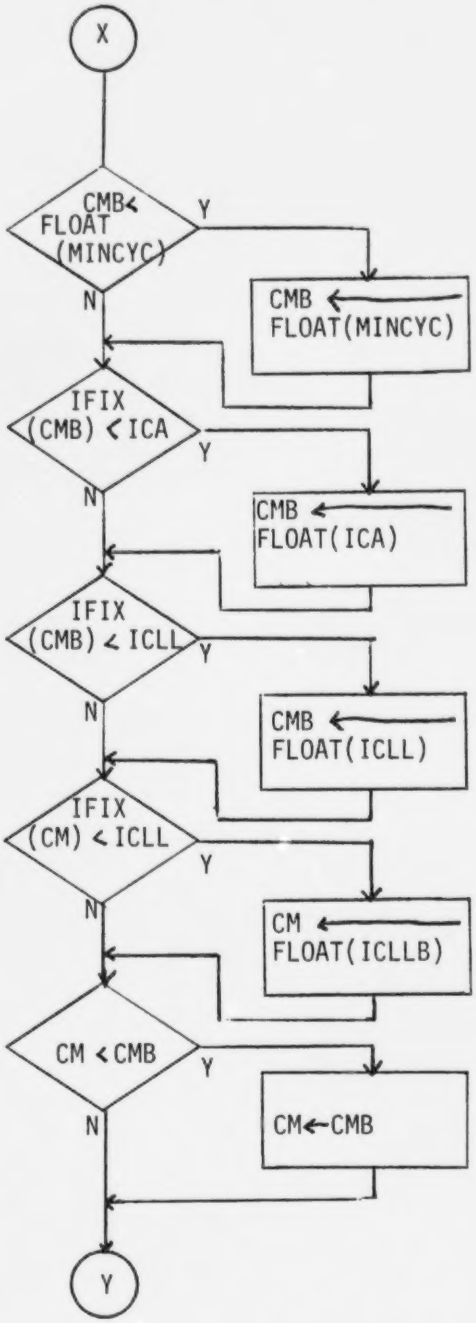
SPRITS


T
ICA ← IFIX (WHIT+XLT+ .499)
ICLL ← IFIX (XLT/(1.0-Y)+ .499)
Y ≥ YMAX
Y
ICLLB ← ICLL
N
Y < YMAX
Y
ICLLB ← IFIX(YMAX*XLT/(YMAX-Y)+.499)
N
CMB ← XLT/(1.0-Y)
W
ICMB = IFIX (CMB + .4999)
WRM ← 0
INDX ← 0
GRN ← CMB - XLT
U

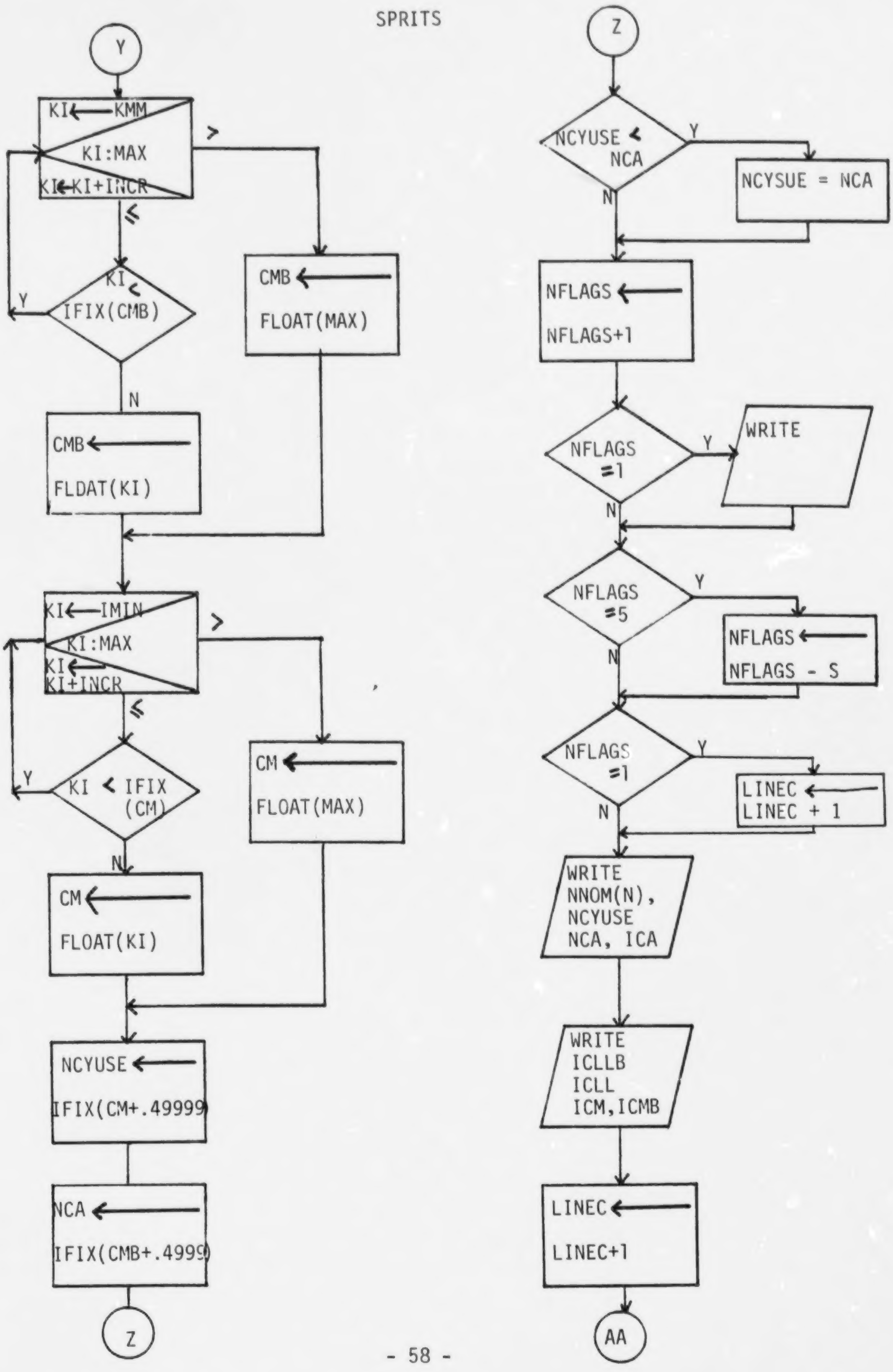

U
J ← 1
J:6
J ← J+1
>
≤
SRS(J) < 0.0
Y
N
ABS (SRS(J).LT.0) < 0.0001
Y
N
IGN ← IFIX(SRS(J)/Y*GRN+0.4999)
IGN ≥ MINGS (J)
Y
N
WM ← MINGS(J)/SRS (J)
WM < WRM
Y
N
WRM ← WM
INDX ← J
V

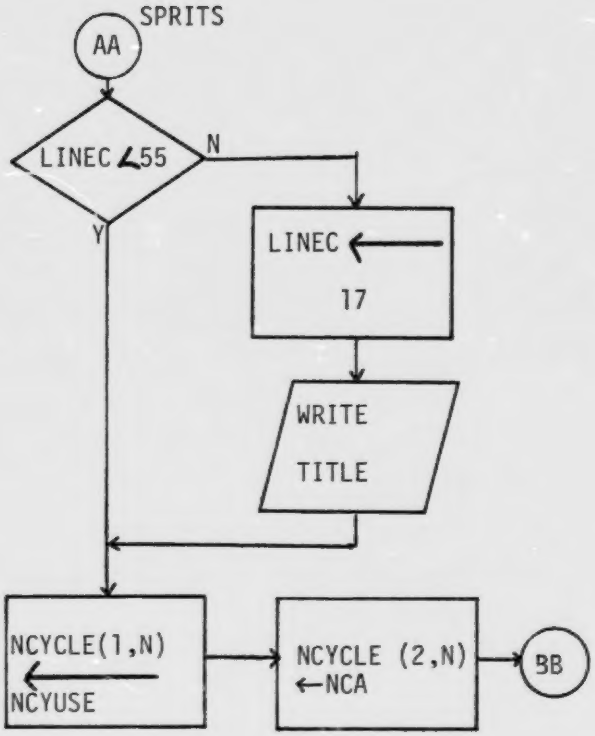
SPRITS

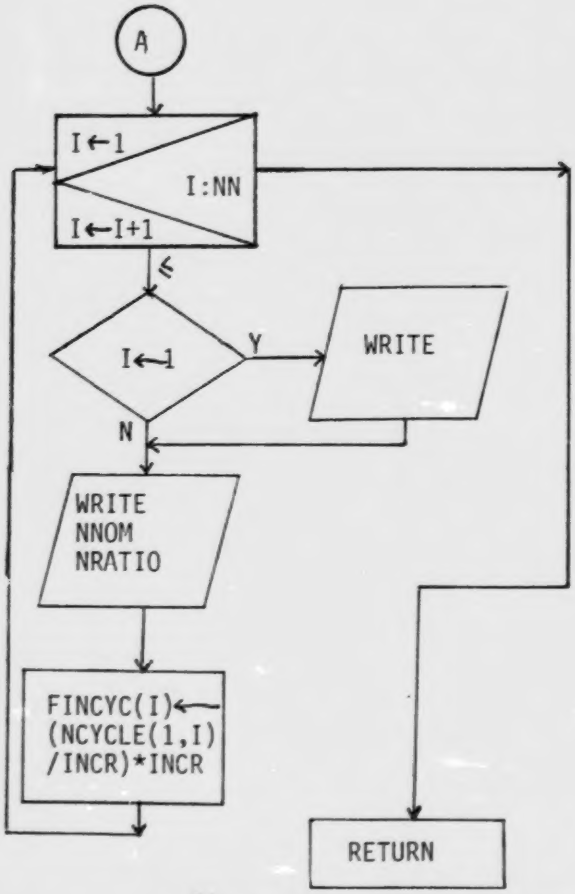

V
INDX = 0
Y
N
SRS(INDX)
-SRS(INDX)
Y
Y+SRS
(INDX)
XLT
XLT+MINGS
(INDX)
W
Y < YMAX
Y
N
CM
CMB
CM
YMAX*XLT
(YMAX-Y)
ICM
IFIX(CM+.499)
X


X
CMB<
FLOAT
(MINCYC)
Y
N
CMB
FLOAT(MINCYC)
IFIX
(CMB) < ICA
Y
N
CMB
FLOAT(ICA)
IFIX
(CMB) < ICLL
Y
N
CMB
FLOAT(ICLL)
IFIX
(CM) < ICLL
Y
N
CM
FLOAT(ICLLB)
CM < CMB
Y
N
CM←CMB
Y

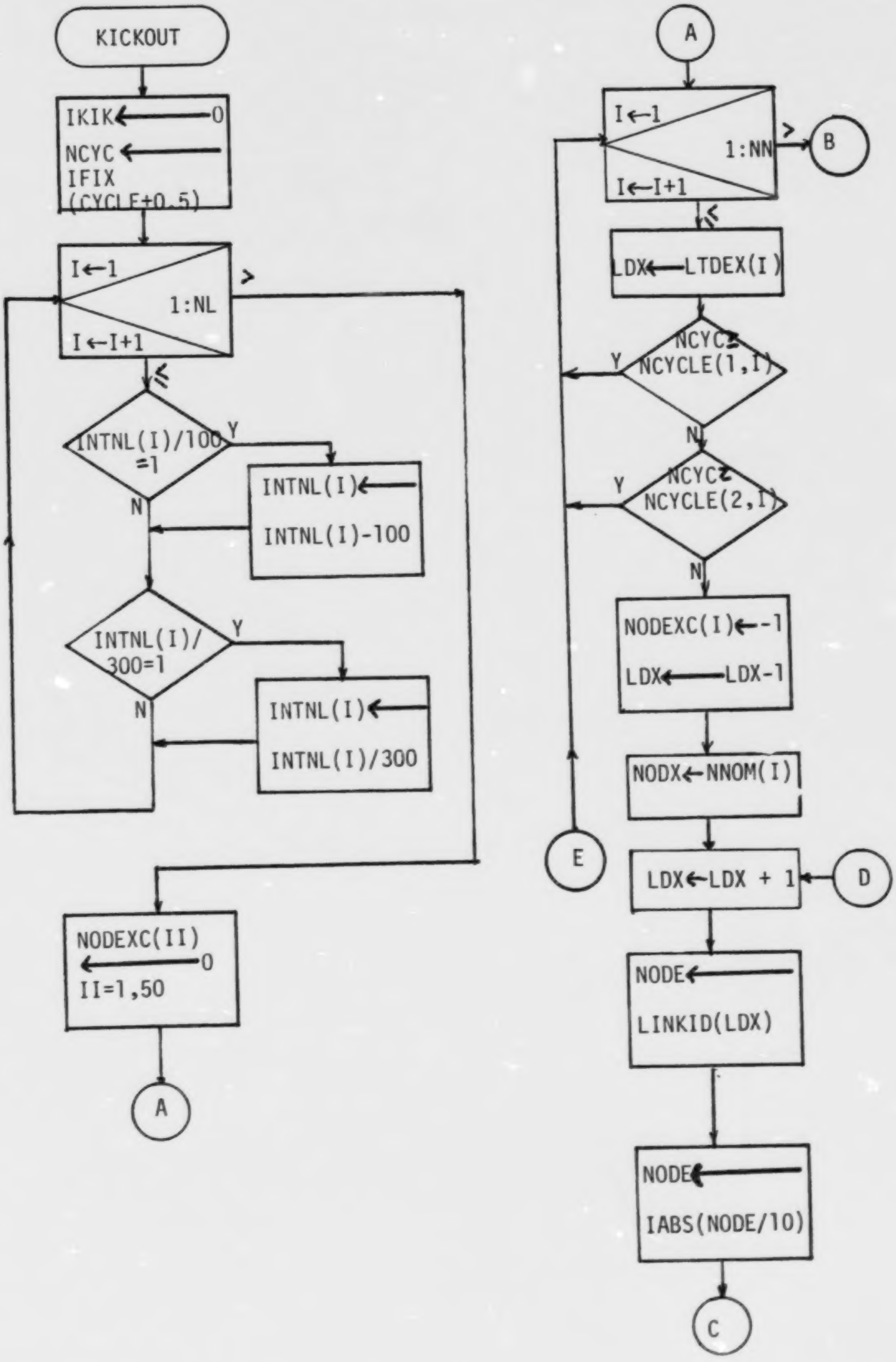
SPRITS


Y
KI ← KMM
KI:MAX
KI ← KI+INCR
>
≤
KI < IFIX(CMB)
Y
N
CMB ← FLOAT(MAX)
CMB ← FLDAT(KI)
KI ← IMIN
KI:MAX
KI ← KI+INCR
>
≤
KI < IFIX (CM)
Y
N
CM ← FLOAT(MAX)
CM ← FLOAT(KI)
NCYUSE ← IFIX(CM+.49999)
NCA ← IFIX(CMB+.4999)
Z
Z
NCYUSE < NCA
Y
N
NCYSUE = NCA
NFLAGS ← NFLAGS+1
NFLAGS =1
Y
N
WRITE
NFLAGS =5
Y
N
NFLAGS ← NFLAGS - S
NFLAGS =1
Y
N
LINEC ← LINEC + 1
WRITE NNOM(N), NCYUSE NCA, ICA
WRITE ICLLB ICLL ICM,ICMB
LINEC ← LINEC+1
AA

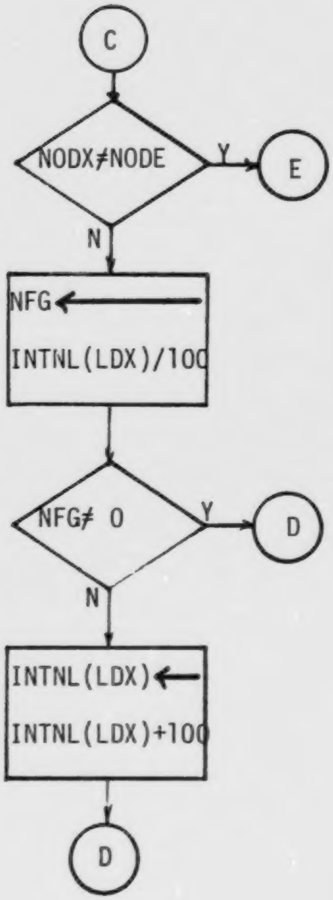

SPRITS
AA
LINEC < 55
N
Y
LINEC ←
17
WRITE
TITLE
NCYCLE(1,N)
←
NCYUSE
NCYCLE (2,N)
←NCA
BB

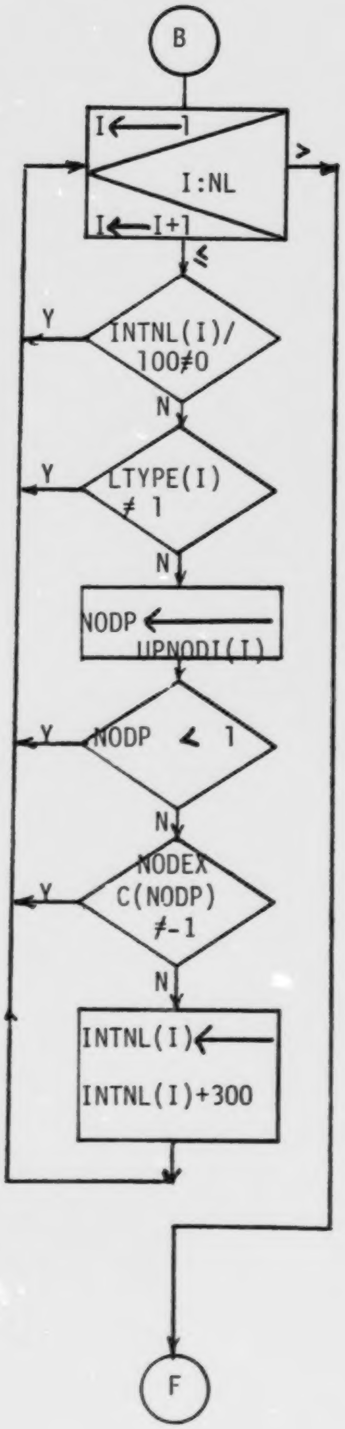

A
I←1
I:NN
I←I+1
≤
I←1
Y
WRITE
N
WRITE
NNOM
NRATIO
FINCYC(I)←
(NCYCLE(1,I)
/INCR)*INCR
RETURN

KICKOUT

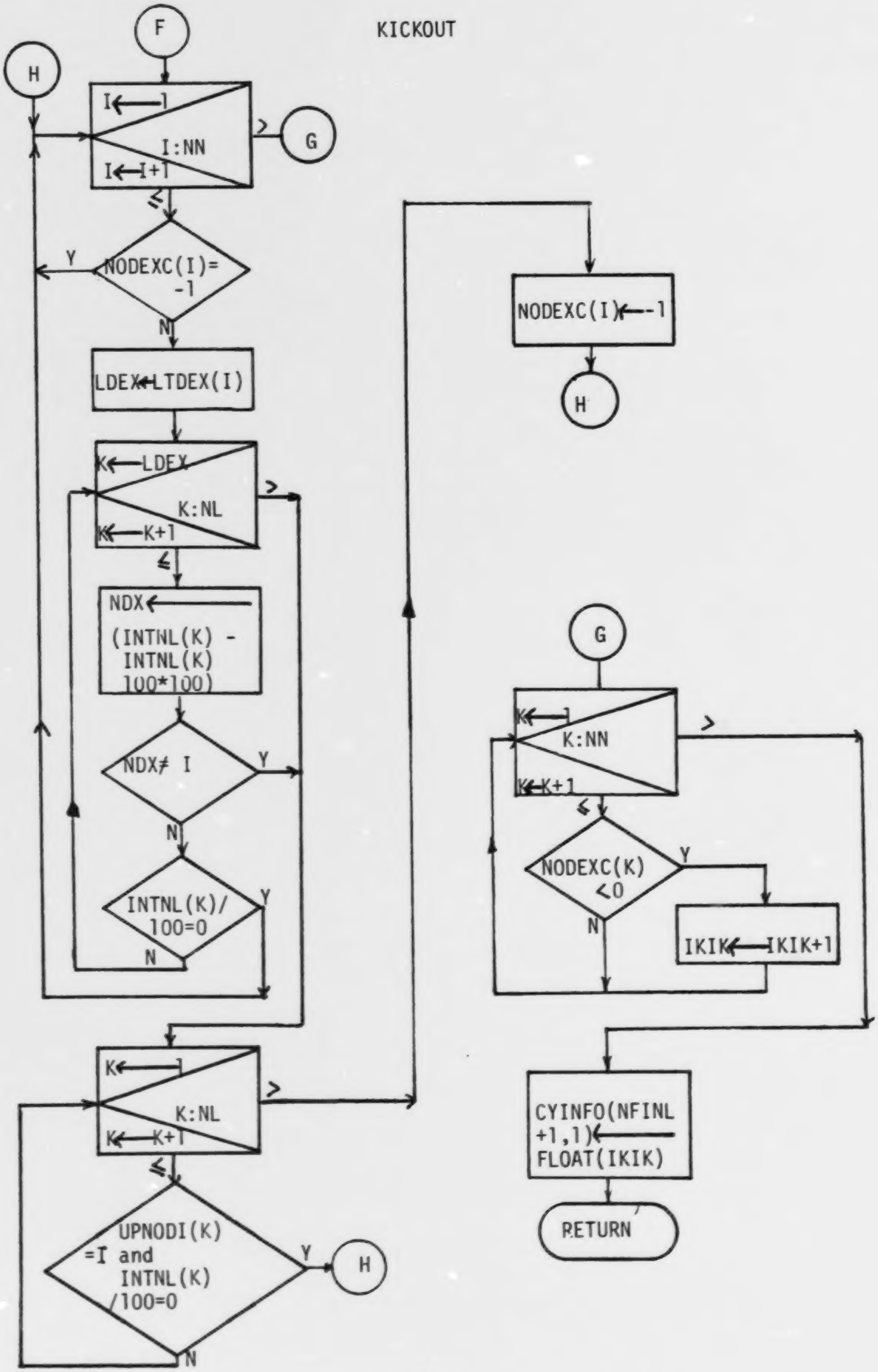

KICKOUT
IKIK ← 0
NCYC ← IFIX (CYCLE+0.5)
I←1
1:NL
I←I+1
>
≤
INTNL(I)/100 =1
Y
N
INTNL(I) ← INTNL(I)-100
INTNL(I)/300=1
Y
N
INTNL(I) ← INTNL(I)/300
NODEXC(II) ← 0
II=1,50
A
A
I←1
1:NN
I←I+1
>
B
≤
LDX ← LTDEX(I)
NCYC≥ NCYCLE(1,I)
Y
N
NCYC≥ NCYCLE(2,I)
Y
N
NODEXC(I) ← -1
LDX ← LDX-1
NODX ← NNOM(I)
LDX ← LDX + 1
D
E
NODE ← LINKID(LDX)
NODE ← IABS(NODE/10)
C

KICKOUT

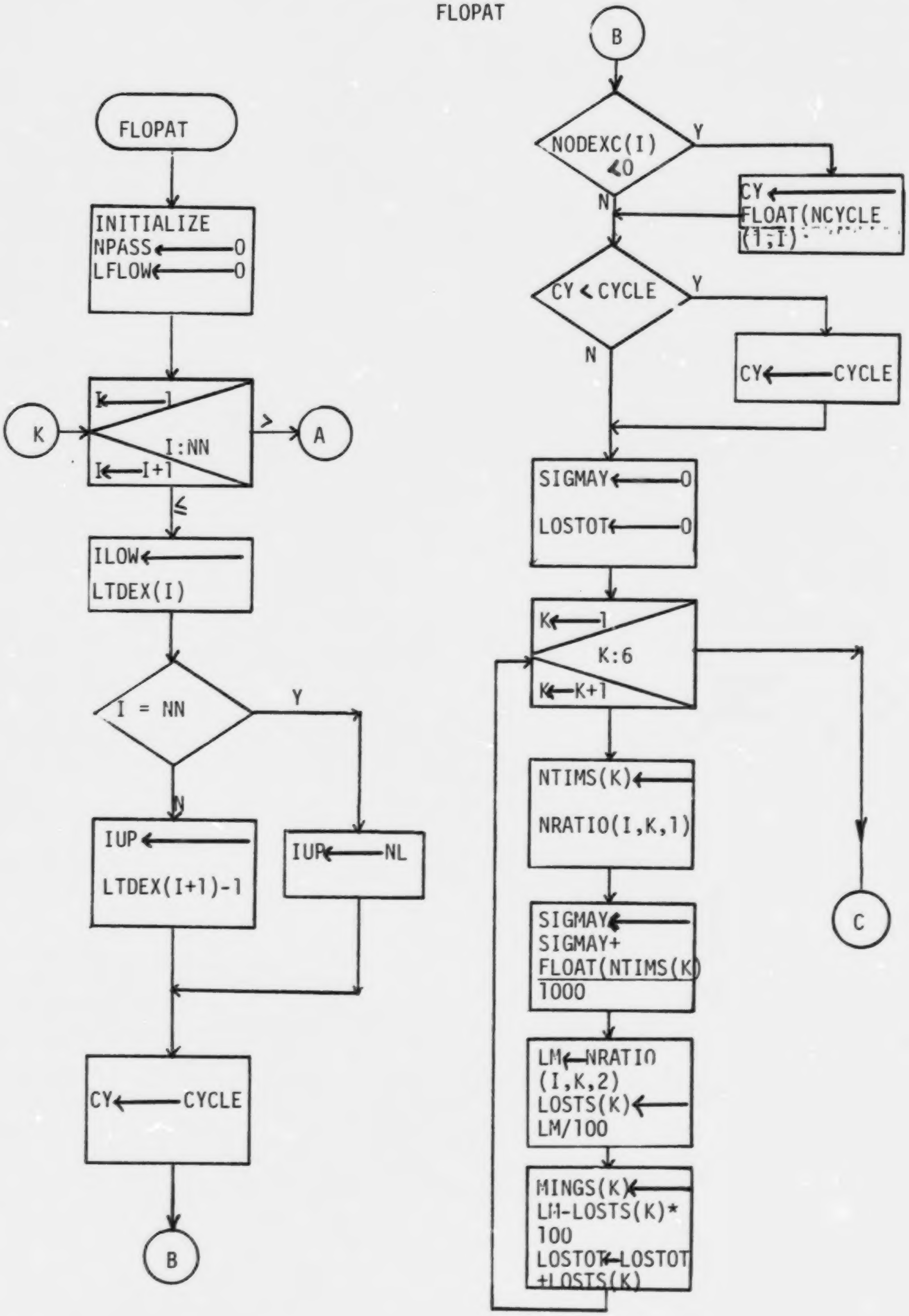

C
NODX≠NODE
Y
E
N
NFG ←
INTNL(LDX)/100
NFG≠ 0
Y
D
N
INTNL(LDX) ←
INTNL(LDX)+100
D


B
I ← 1
I:NL
I ← I+1
>
≤
INTNL(I)/100≠0
Y
N
LTYPE(I) ≠ 1
Y
N
NODP ← UPNODI(I)
NODP < 1
Y
N
NODEXC(NODP) ≠-1
Y
N
INTNL(I) ← INTNL(I)+300
F

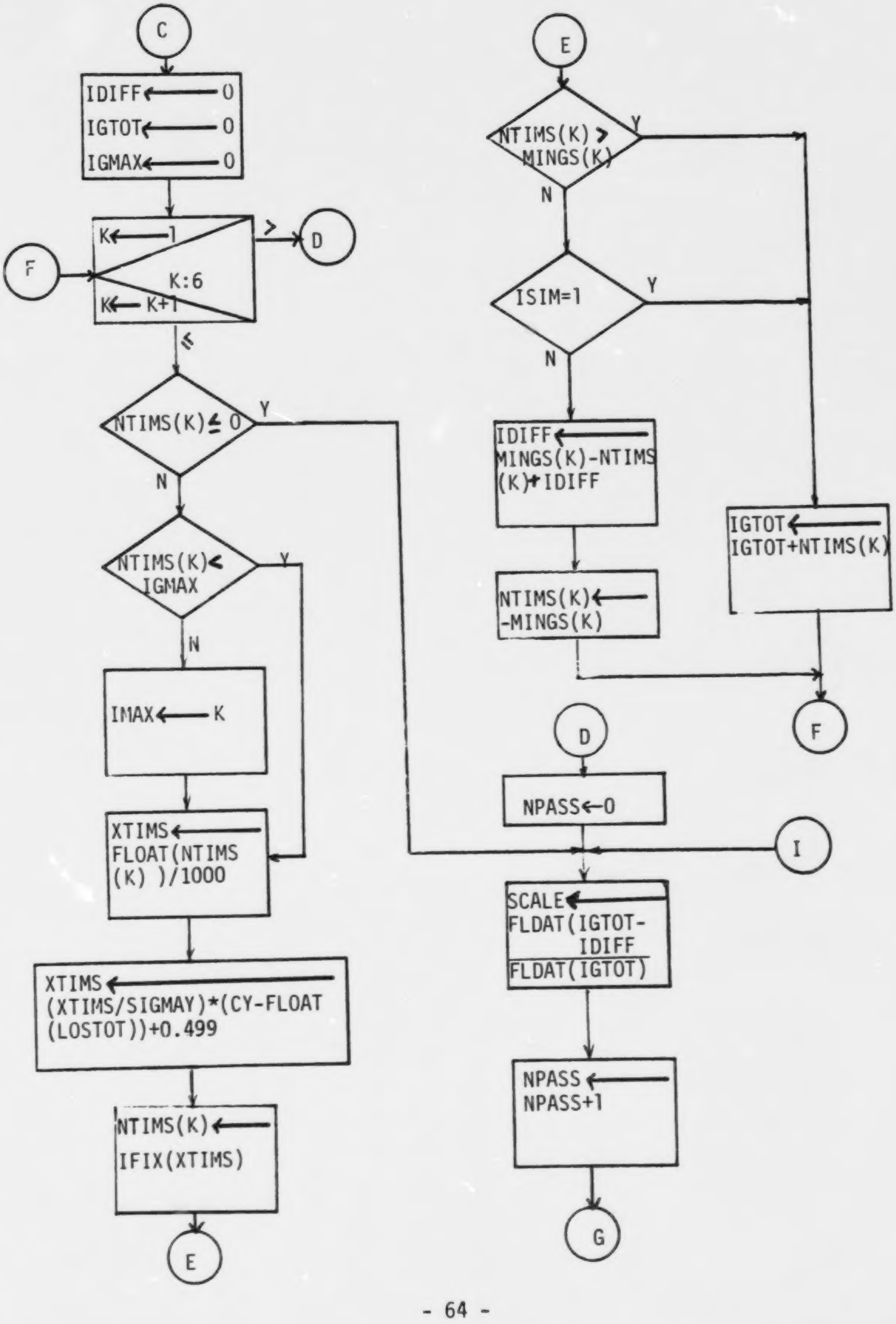
KICKOUT


F
H
I←1
I:NN
I←I+1
>
G
≤
NODEXC(I)=
-1
Y
N
LDEX←LTDEX(I)
K←LDEX
K:NL
K←K+1
>
≤
NDX←
(INTNL(K) -
INTNL(K)
100*100)
NDX≠ I
Y
N
INTNL(K)/
100=0
Y
N
K←1
K:NL
K←K+1
>
≤
UPNODI(K)
=I and
INTNL(K)
/100=0
Y
N
H
NODEXC(I)←-1
H
G
K←1
K:NN
K←K+1
>
≤
NODEXC(K)
<0
Y
N
IKIK←IKIK+1
CYINFO(NFINL
+1,1)←
FLOAT(IKIK)
RETURN

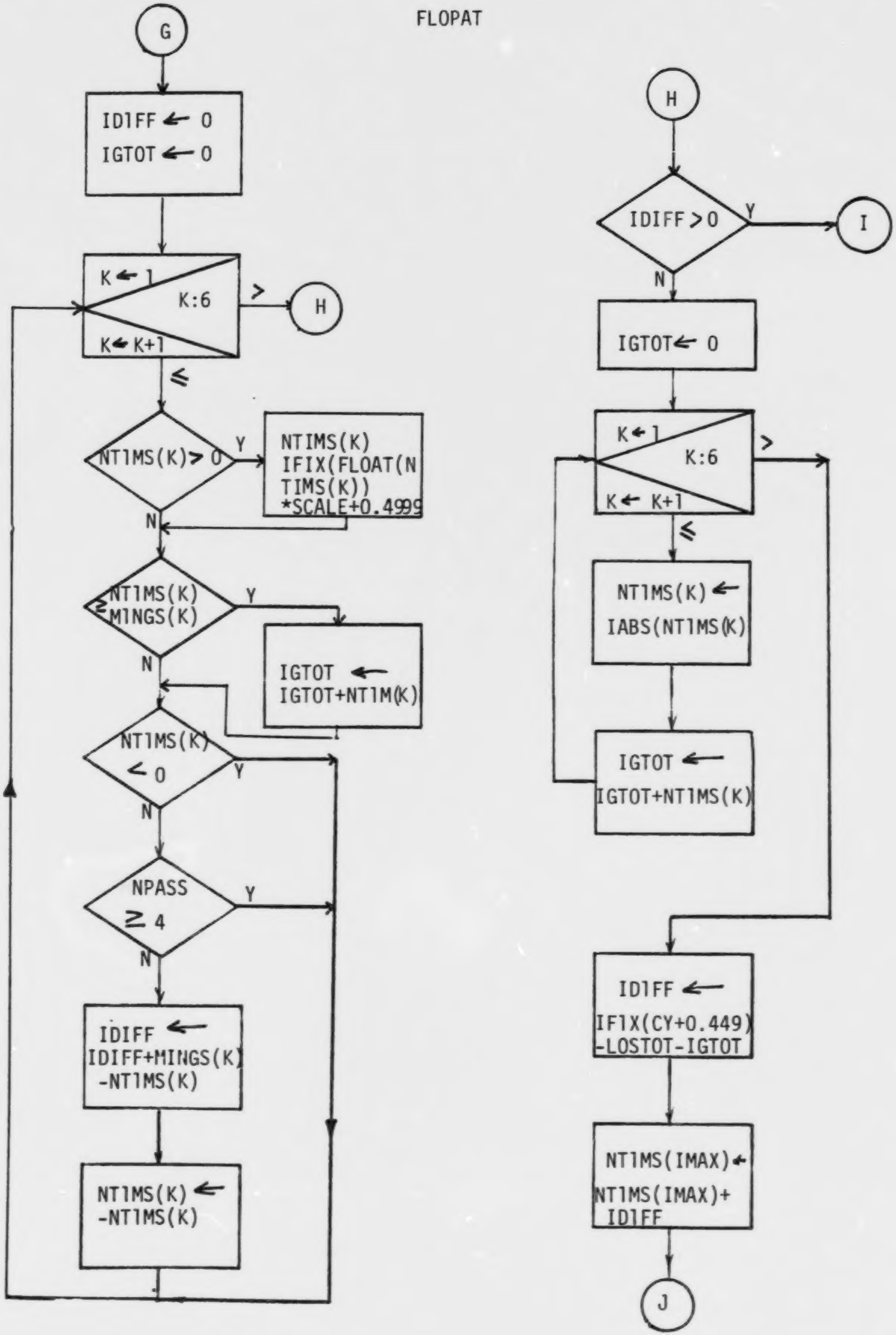
FLOPAT


FLOPAT
INITIALIZE
NPASS ← 0
LFLOW ← 0
K
I ← 1
I:NN
I ← I+1
>
A
≤
ILOW ← LTDEX(I)
I = NN
Y
N
IUP ← LTDEX(I+1)-1
IUP ← NL
CY ← CYCLE
B
B
NODEXC(I) < 0
Y
N
CY ← FLOAT(NCYCLE (1,I)
CY < CYCLE
Y
N
CY ← CYCLE
SIGMAY ← 0
LOSTOT ← 0
K ← 1
K:6
K ← K+1
NTIMS(K) ← NRATIO(I,K,1)
SIGMAY ← SIGMAY+ FLOAT(NTIMS(K) / 1000
LM ← NRATIO (I,K,2)
LOSTS(K) ← LM/100
MINGS(K) ← LM-LOSTS(K)* 100
LOSTOT ← LOSTOT +LOSTS(K)
C

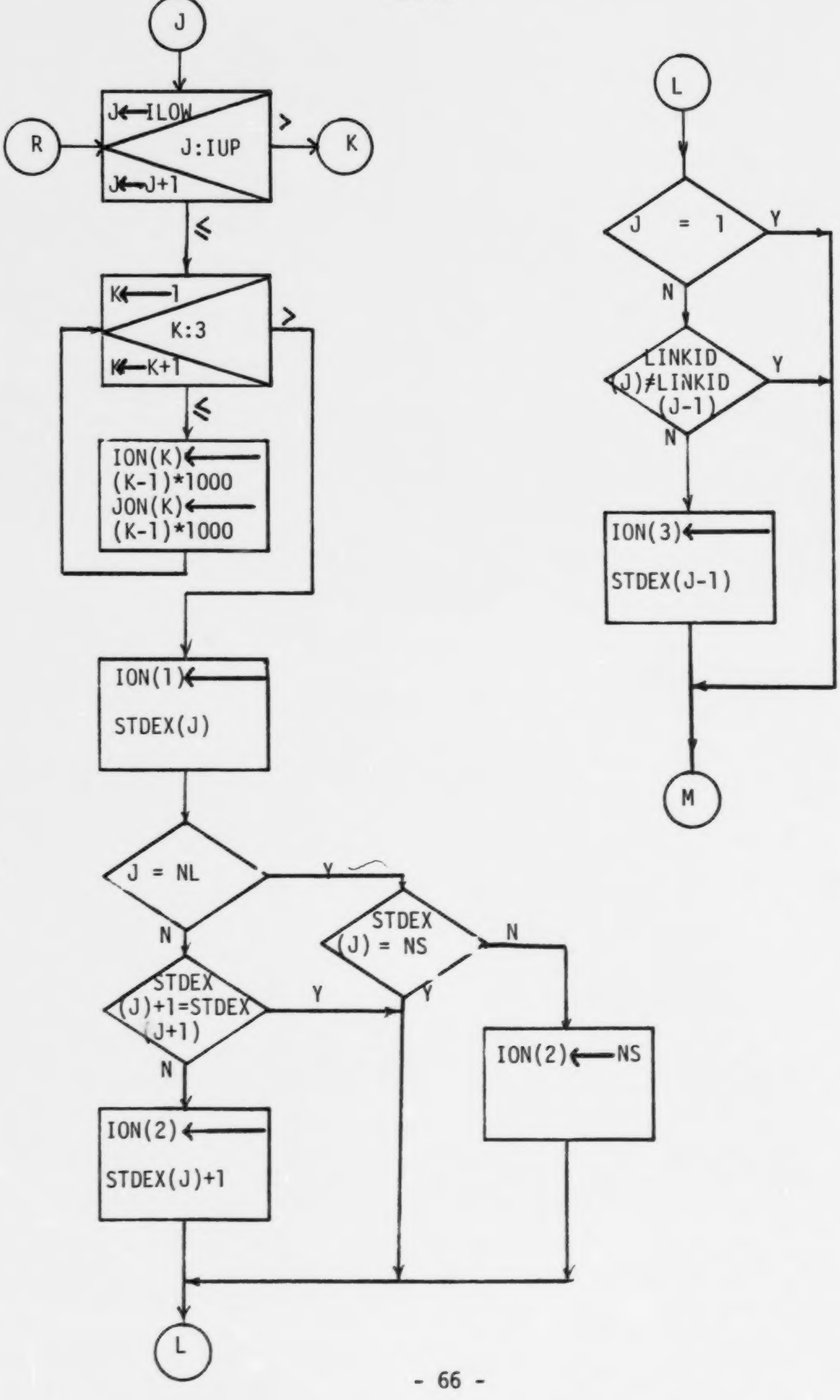
FLOPAT


C
IDIFF ← 0
IGTOT ← 0
IGMAX ← 0
K ← 1
K:6
K ← K+1
>
D
F
≤
NTIMS(K) ≤ 0
Y
N
NTIMS(K) < IGMAX
Y
N
IMAX ← K
XTIMS ← FLOAT(NTIMS (K))/1000
XTIMS ← (XTIMS/SIGMAY)*(CY-FLOAT (LOSTOT))+0.499
NTIMS(K) ← IFIX(XTIMS)
E
E
NTIMS(K) > MINGS(K)
Y
N
ISIM=1
Y
N
IDIFF ← MINGS(K)-NTIMS (K)+IDIFF
NTIMS(K) ← -MINGS(K)
IGTOT ← IGTOT+NTIMS(K)
F
D
NPASS ← 0
I
SCALE ← FLDAT(IGTOT-IDIFF) / FLDAT(IGTOT)
NPASS ← NPASS+1
G

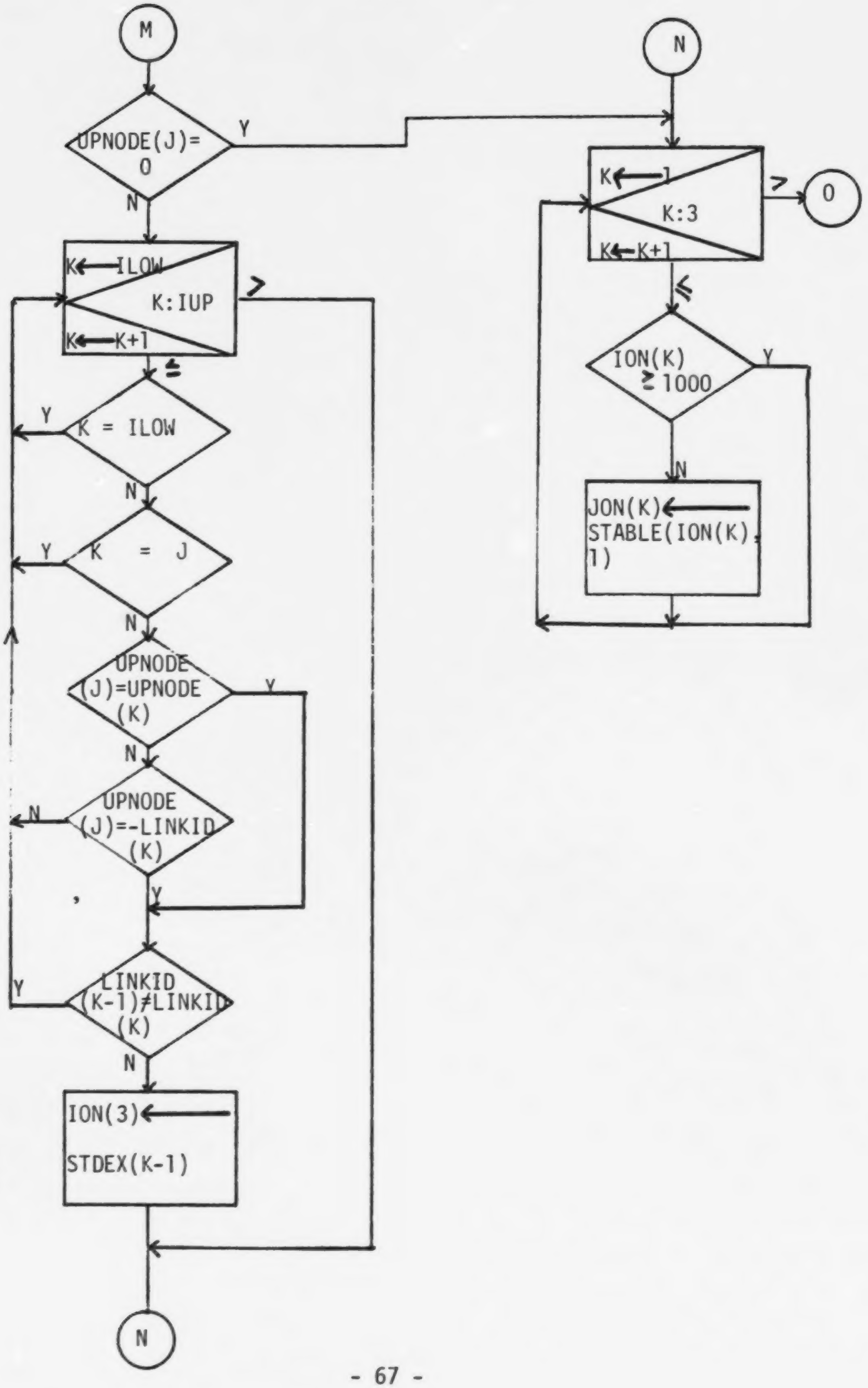
FLOPAT


G
IDIFF ← 0
IGTOT ← 0
K ← 1
K:6
K ← K+1
>
H
≤
NTIMS(K) > 0
Y
NTIMS(K)
IFIX(FLOAT(N
TIMS(K))
*SCALE+0.4999
N
NTIMS(K)
≥ MINGS(K)
Y
IGTOT ←
IGTOT+NTIM(K)
N
NTIMS(K)
< 0
Y
N
NPASS
≥ 4
Y
N
IDIFF ←
IDIFF+MINGS(K)
-NTIMS(K)
NTIMS(K) ←
-NTIMS(K)
H
IDIFF > 0
Y
I
N
IGTOT ← 0
K ← 1
K:6
K ← K+1
>
≤
NTIMS(K) ←
IABS(NTIMS(K))
IGTOT ←
IGTOT+NTIMS(K)
IDIFF ←
IFIX(CY+0.449)
-LOSTOT-IGTOT
NTIMS(IMAX) ←
NTIMS(IMAX)+
IDIFF
J

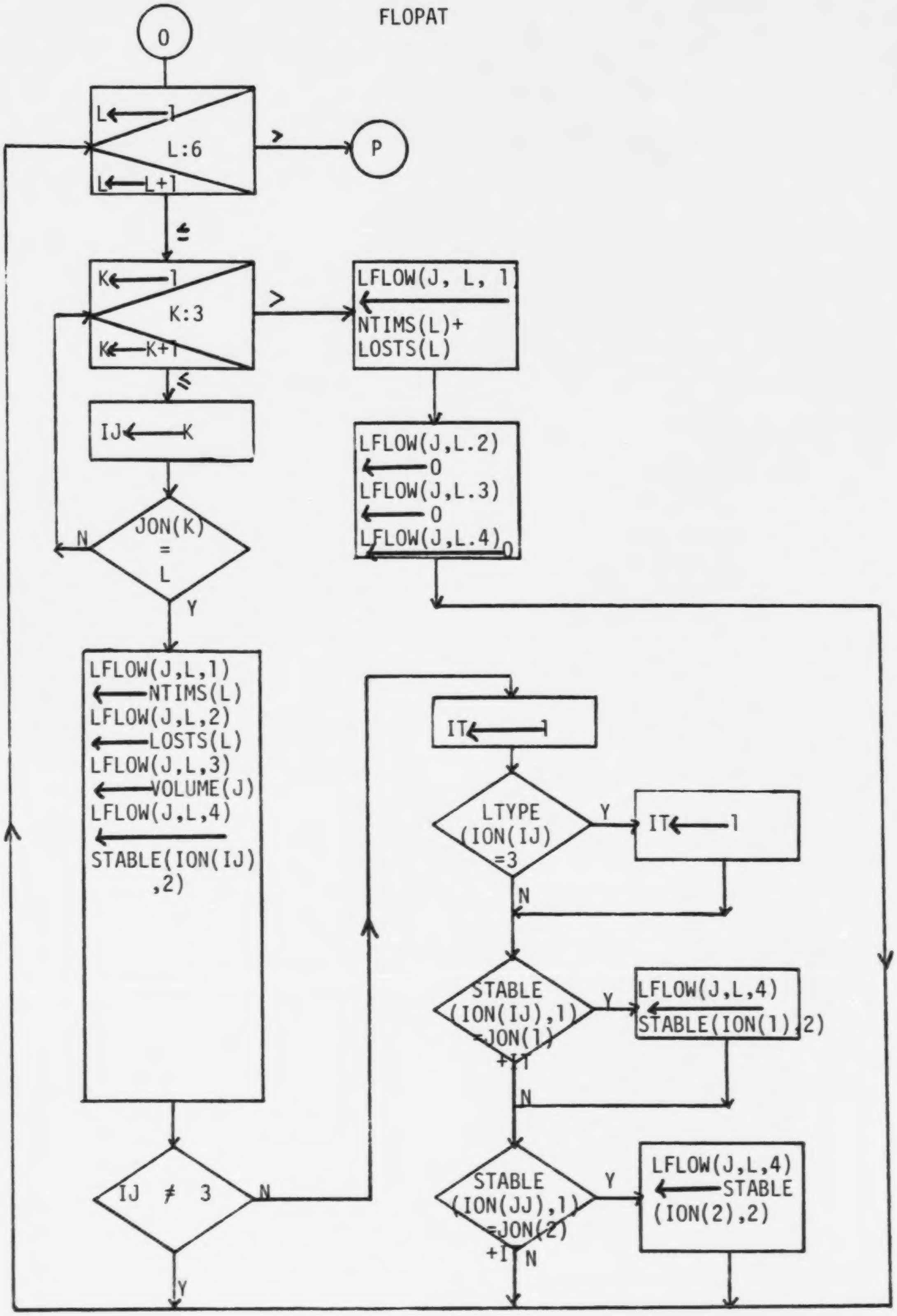
FLOPAT


J
R
J←ILOW
J:IUP
J←J+1
>
K
≤
K←1
K:3
K←K+1
>
≤
ION(K)←
(K-1)*1000
JON(K)←
(K-1)*1000
ION(1)←
STDEX(J)
J = NL
Y
N
STDEX
(J) = NS
N
Y
STDEX
(J)+1=STDEX
(J+1)
Y
N
ION(2)←
STDEX(J)+1
ION(2)←NS
L
L
J = 1
Y
N
LINKID
(J)≠LINKID
(J-1)
Y
N
ION(3)←
STDEX(J-1)
M

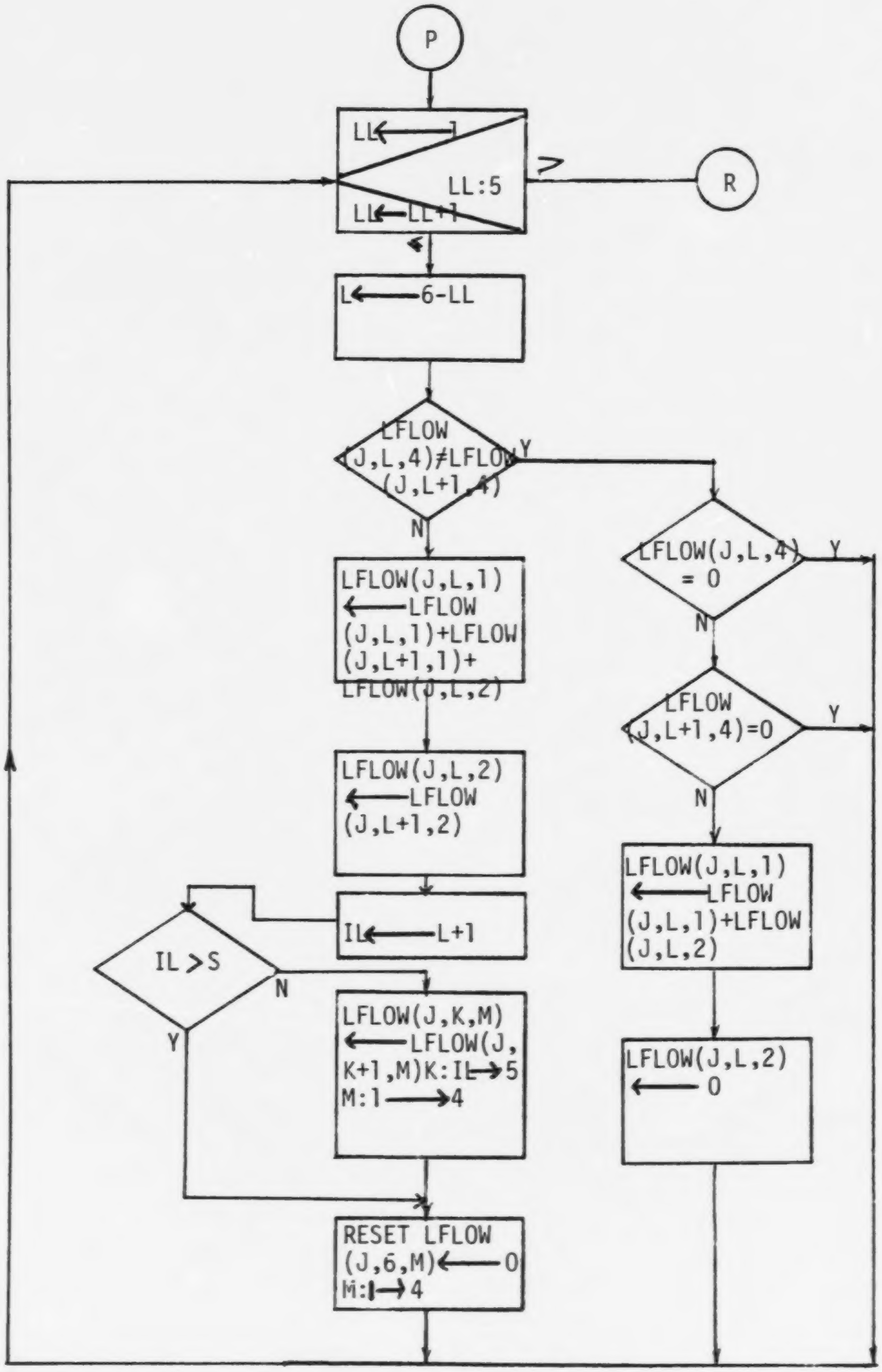
FLOPAT


M
UPNODE(J)= 0
Y
N
K←ILOW
K:IUP
K←K+1
>
≤
K = ILOW
Y
N
K = J
Y
N
UPNODE (J)=UPNODE (K)
Y
N
UPNODE (J)=-LINKID (K)
N
Y
LINKID (K-1)≠LINKID (K)
Y
N
ION(3)← STDEX(K-1)
N
N
K←1
K:3
K←K+1
>
0
≤
ION(K) ≥ 1000
Y
N
JON(K)← STABLE(ION(K), 1)

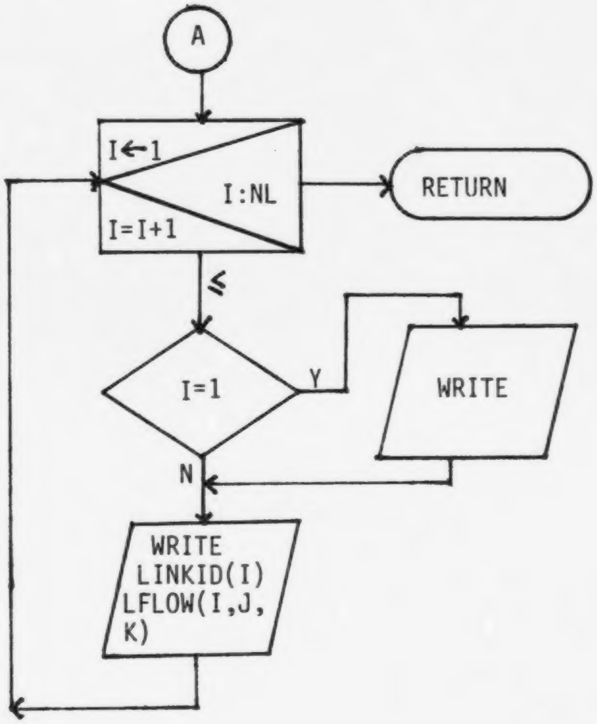
FLOPAT


O
L←1
L:6
L←L+1
>
P
≤
K←1
K:3
K←K+1
>
LFLOW(J, L, 1) ← NTIMS(L)+ LOSTS(L)
≤
IJ←K
LFLOW(J,L.2) ←0
LFLOW(J,L.3) ←0
LFLOW(J,L.4) ←0
JON(K) = L
N
Y
LFLOW(J,L,1) ←NTIMS(L)
LFLOW(J,L,2) ←LOSTS(L)
LFLOW(J,L,3) ←VOLUME(J)
LFLOW(J,L,4) ← STABLE(ION(IJ) ,2)
IT←1
LTYPE (ION(IJ) =3
Y
IT←1
N
STABLE (ION(IJ),1) =JON(1) +IT
Y
LFLOW(J,L,4) ← STABLE(ION(1),2)
N
IJ ≠ 3
N
STABLE (ION(JJ),1) =JON(2) +IT
Y
LFLOW(J,L,4) ←STABLE (ION(2),2)
N
Y

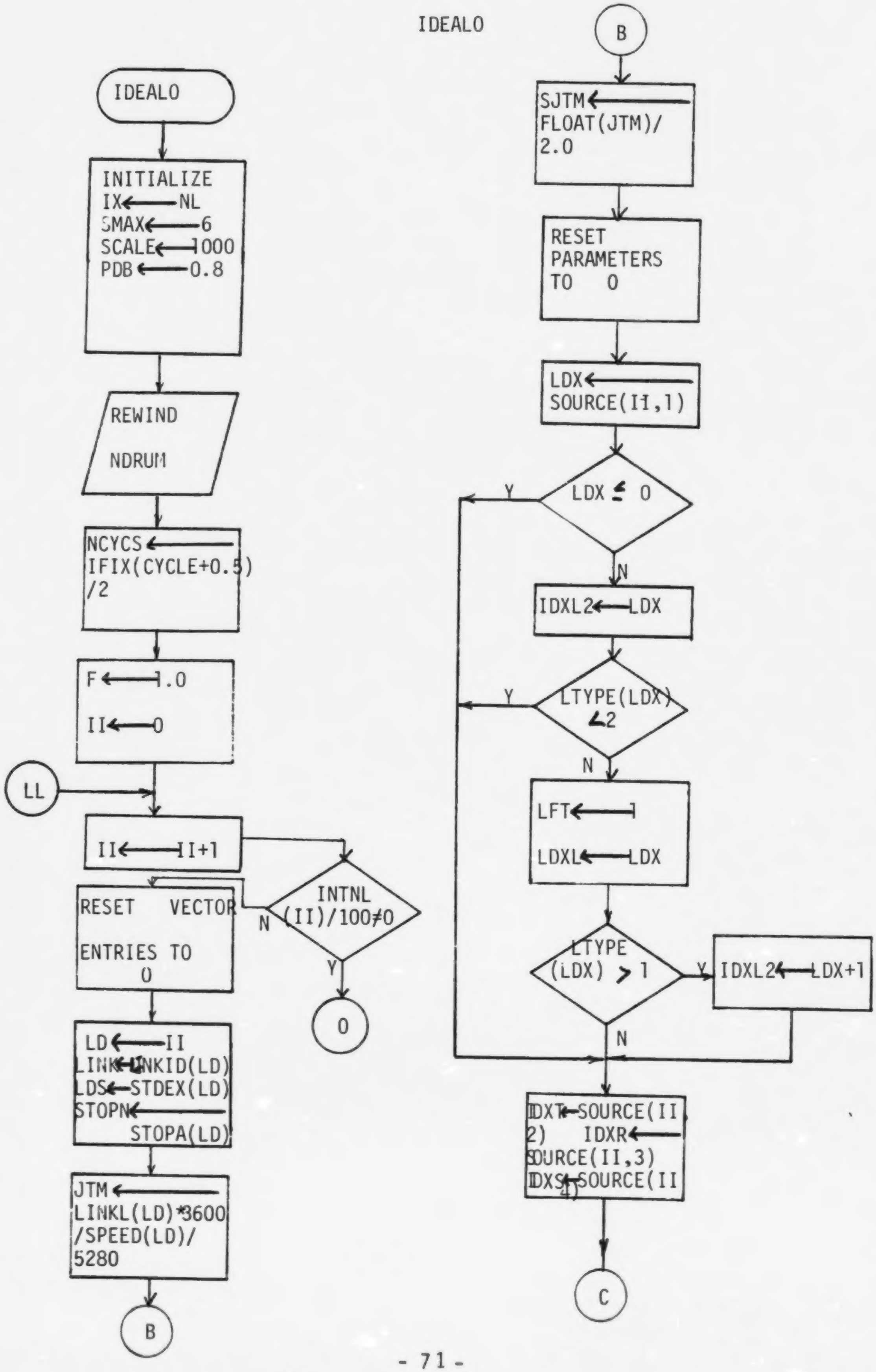
FLOPAT


P
LL ← 1
LL:5
LL ← LL+1
>
R
<
L ← 6-LL
LFLOW (J,L,4)≠LFLOW (J,L+1,4)
Y
N
LFLOW(J,L,4) = 0
Y
N
LFLOW (J,L+1,4)=0
Y
N
LFLOW(J,L,1) ← LFLOW (J,L,1)+LFLOW (J,L+1,1)+ LFLOW(J,L,2)
LFLOW(J,L,2) ← LFLOW (J,L+1,2)
LFLOW(J,L,1) ← LFLOW (J,L,1)+LFLOW (J,L,2)
LFLOW(J,L,2) ← 0
IL ← L+1
IL > S
N
Y
LFLOW(J,K,M) ← LFLOW(J, K+1,M) K:IL → 5 M:1 → 4
RESET LFLOW (J,6,M) ← 0 M:1 → 4

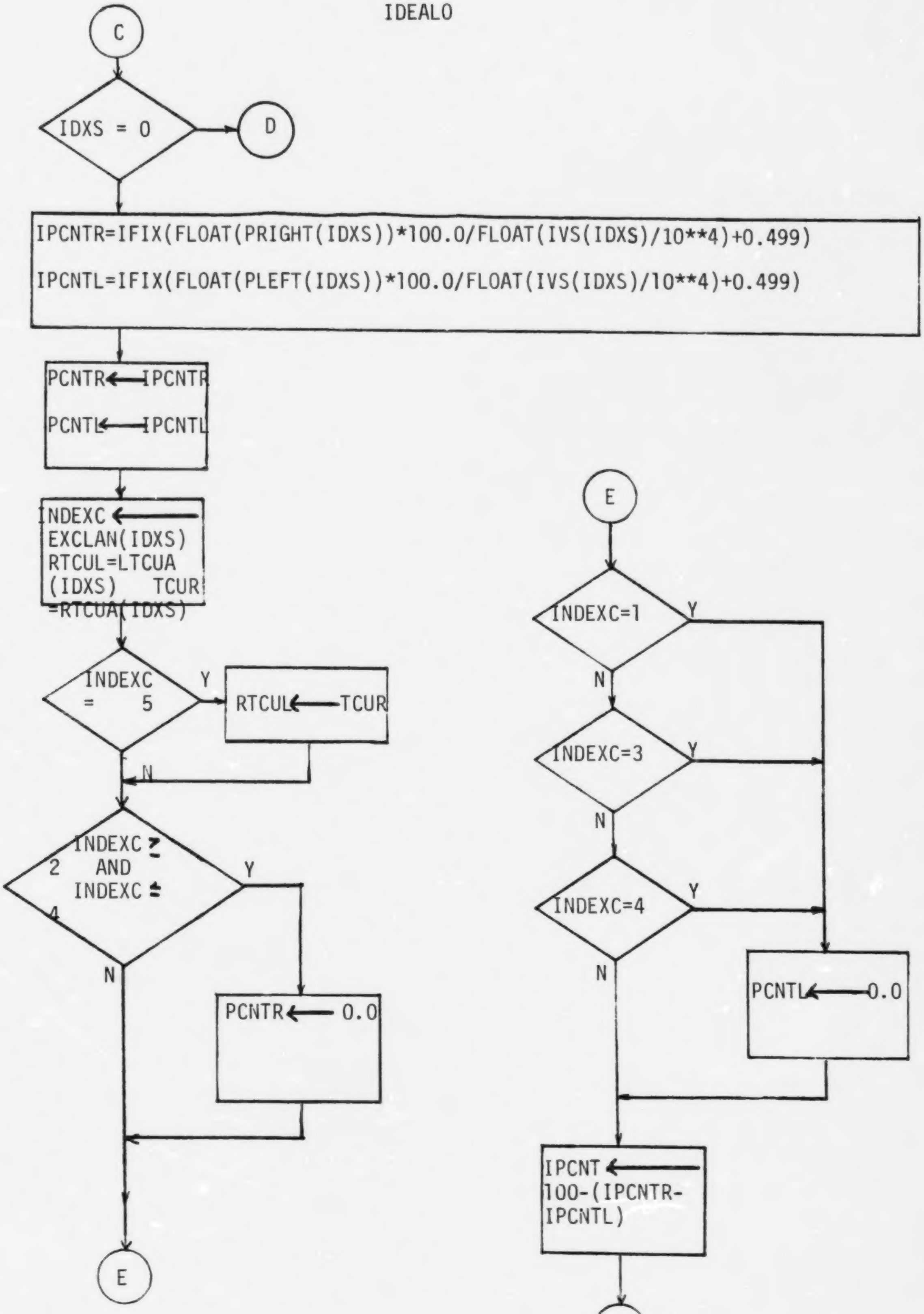
FLOPAT


A
I←1
I:NL
I=I+1
RETURN
≤
I=1
Y
N
WRITE
WRITE
LINKID(I)
LFLOW(I,J,
K)

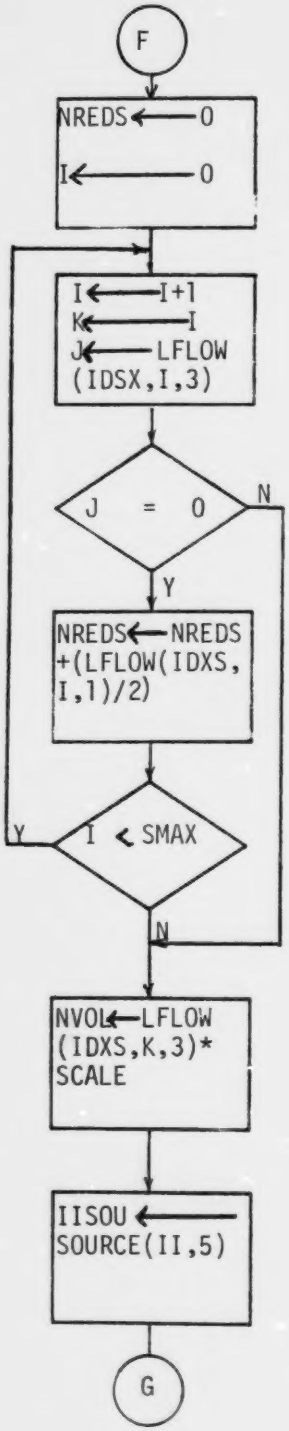
IDEALO

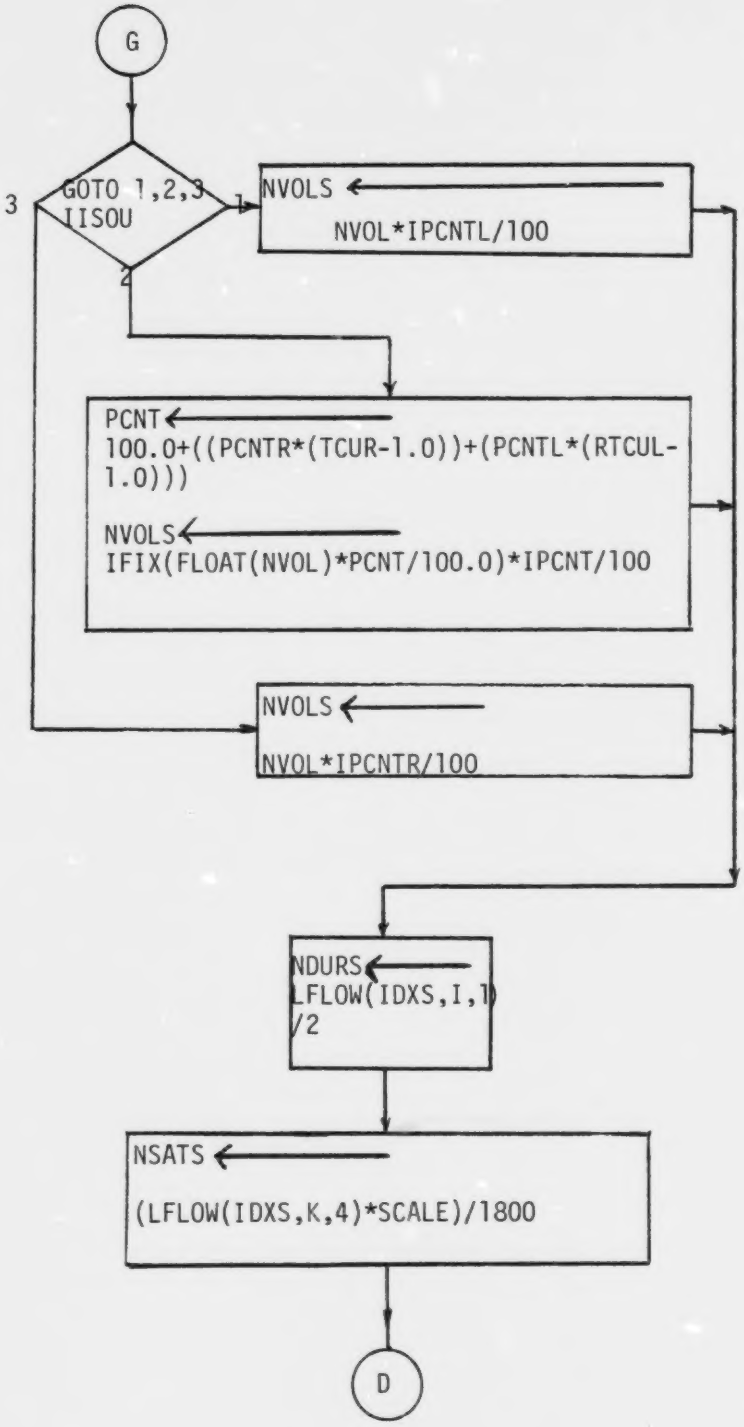

IDEALO
INITIALIZE
IX ← NL
SMAX ← 6
SCALE ← 1000
PDB ← 0.8
REWIND
NDRUM
NCYCS ← IFIX(CYCLE+0.5) /2
F ← 1.0
II ← 0
LL
II ← II+1
INTNL (II)/100≠0
N
Y
0
RESET VECTOR ENTRIES TO 0
LD ← II
LINK ← LINKID(LD)
LDS ← STDEX(LD)
STOPN ← STOPA(LD)
JTM ← LINKL(LD)*3600 /SPEED(LD)/ 5280
B
B
SJTM ← FLOAT(JTM)/ 2.0
RESET PARAMETERS TO 0
LDX ← SOURCE(II,1)
LDX ≤ 0
Y
N
IDXL2 ← LDX
LTYPE(LDX) < 2
Y
N
LFT ← 1
LDXL ← LDX
LTYPE (LDX) > 1
Y
IDXL2 ← LDX+1
N
IDXT ← SOURCE(II, 2) IDXR ← SOURCE(II,3) IDXS ← SOURCE(II 4)
C

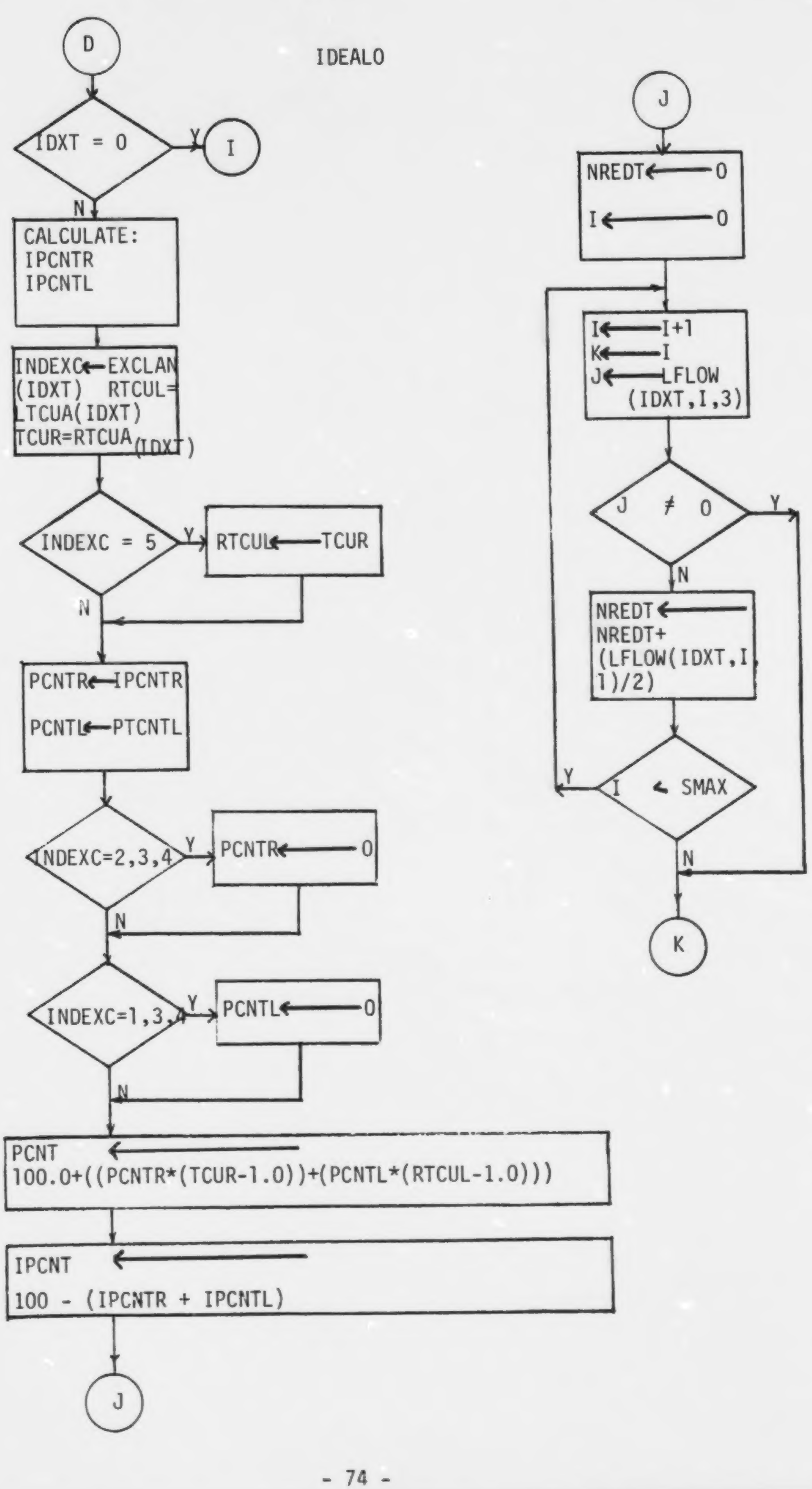
IDEALO


C
IDXS = 0
D
IPCNTR=IFIX(FLOAT(PRIGHT(IDXS))*100.0/FLOAT(IVS(IDXS)/10**4)+0.499)
IPCNTL=IFIX(FLOAT(PLEFT(IDXS))*100.0/FLOAT(IVS(IDXS)/10**4)+0.499)
PCNTR ← IPCNTR
PCNTL ← IPCNTL
INDEXC ← EXCLAN(IDXS) RTCUL=LTCUA (IDXS) TCUR =RTCUA(IDXS)
INDEXC = 5
Y
RTCUL ← TCUR
N
INDEXC ≥ 2 AND INDEXC ≤ 4
Y
PCNTR ← 0.0
N
E
E
INDEXC=1
Y
N
INDEXC=3
Y
N
INDEXC=4
Y
N
PCNTL ← 0.0
IPCNT ← 100-(IPCNTR-IPCNTL)
F

IDEALO


F
NREDS ← 0
I ← 0
I ← I+1
K ← I
J ← LFLOW (IDSX,I,3)
J = 0
N
Y
NREDS ← NREDS +(LFLOW(IDXS, I,1)/2)
I < SMAX
Y
N
NVOL ← LFLOW (IDXS,K,3)* SCALE
IISOU ← SOURCE(II,5)
G

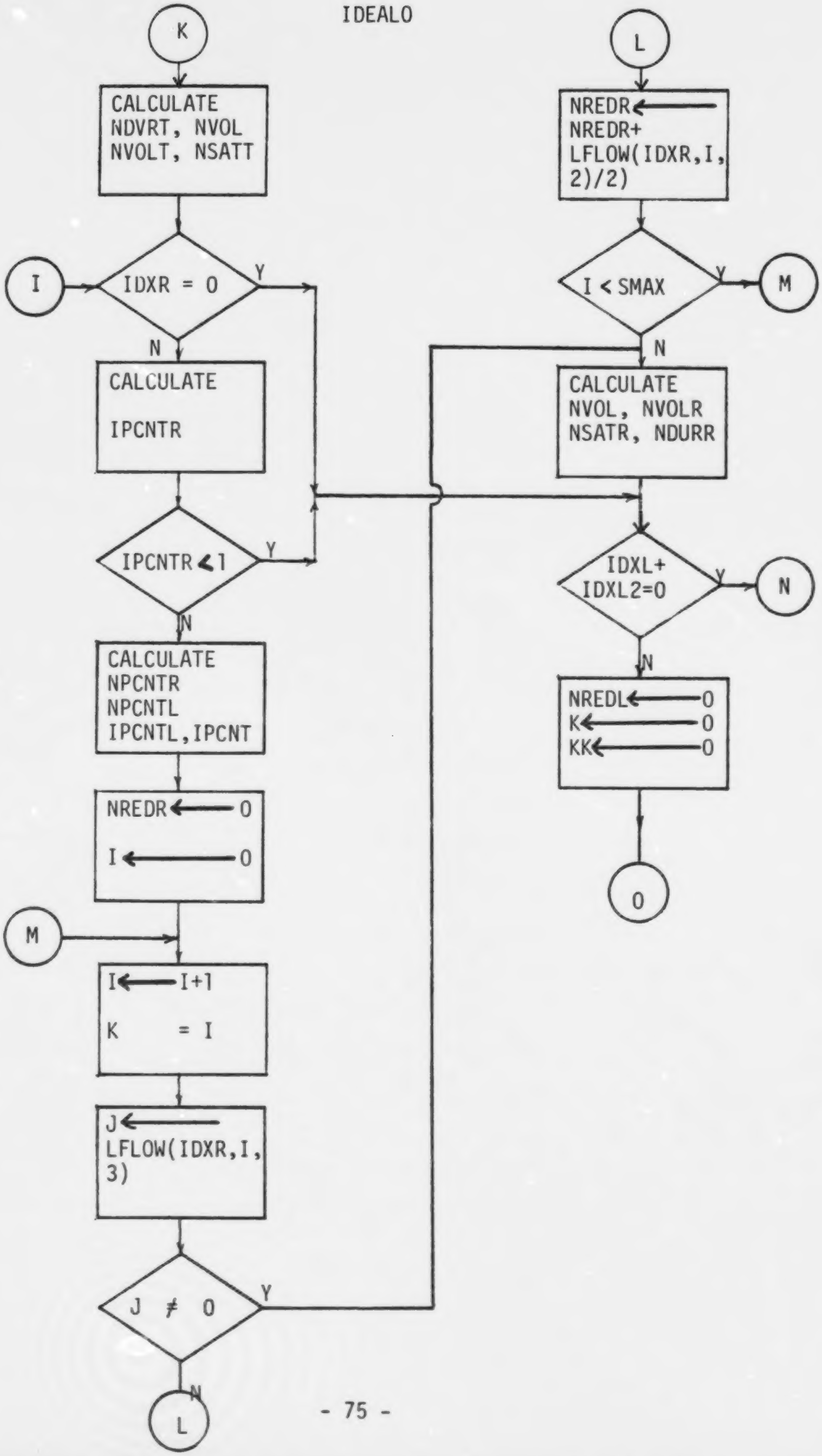

G
GOTO 1,2,3 IISOU
3
1
2
NVOLS ← NVOL*IPCNTL/100
PCNT ← 100.0+((PCNTR*(TCUR-1.0))+(PCNTL*(RTCUL-1.0)))
NVOLS ← IFIX(FLOAT(NVOL)*PCNT/100.0)*IPCNT/100
NVOLS ← NVOL*IPCNTR/100
NDURS ← LFLOW(IDXS,I,1) /2
NSATS ← (LFLOW(IDXS,K,4)*SCALE)/1800
D



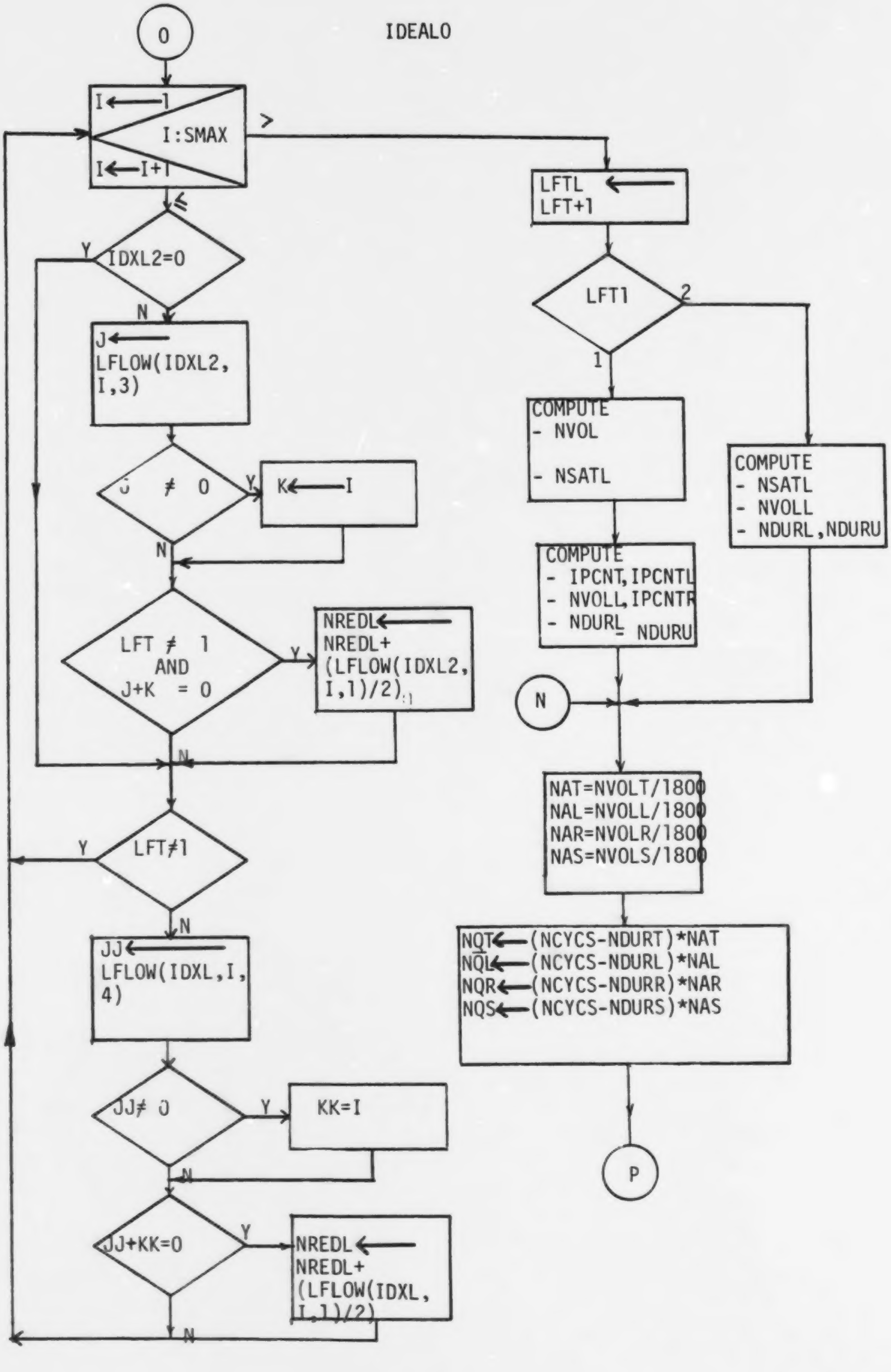
IDEALO

D
IDXT = 0
Y
I
N
CALCULATE:
IPCNTR
IPCNTL
INDEXC←EXCLAN (IDXT) RTCUL=LTCUA(IDXT) TCUR=RTCUA(IDXT)
INDEXC = 5
Y
RTCUL←TCUR
N
PCNTR←IPCNTR
PCNTL←PTCNTL
INDEXC=2,3,4
Y
PCNTR←0
N
INDEXC=1,3,4
Y
PCNTL←0
N
PCNT ← 100.0+((PCNTR*(TCUR-1.0))+(PCNTL*(RTCUL-1.0)))
IPCNT ← 100 - (IPCNTR + IPCNTL)
J
J
NREDT←0
I←0
I←I+1
K←I
J←LFLOW (IDXT,I,3)
J ≠ 0
Y
N
NREDT ← NREDT+ (LFLOW(IDXT,I, 1)/2)
Y
I ≤ SMAX
N
K

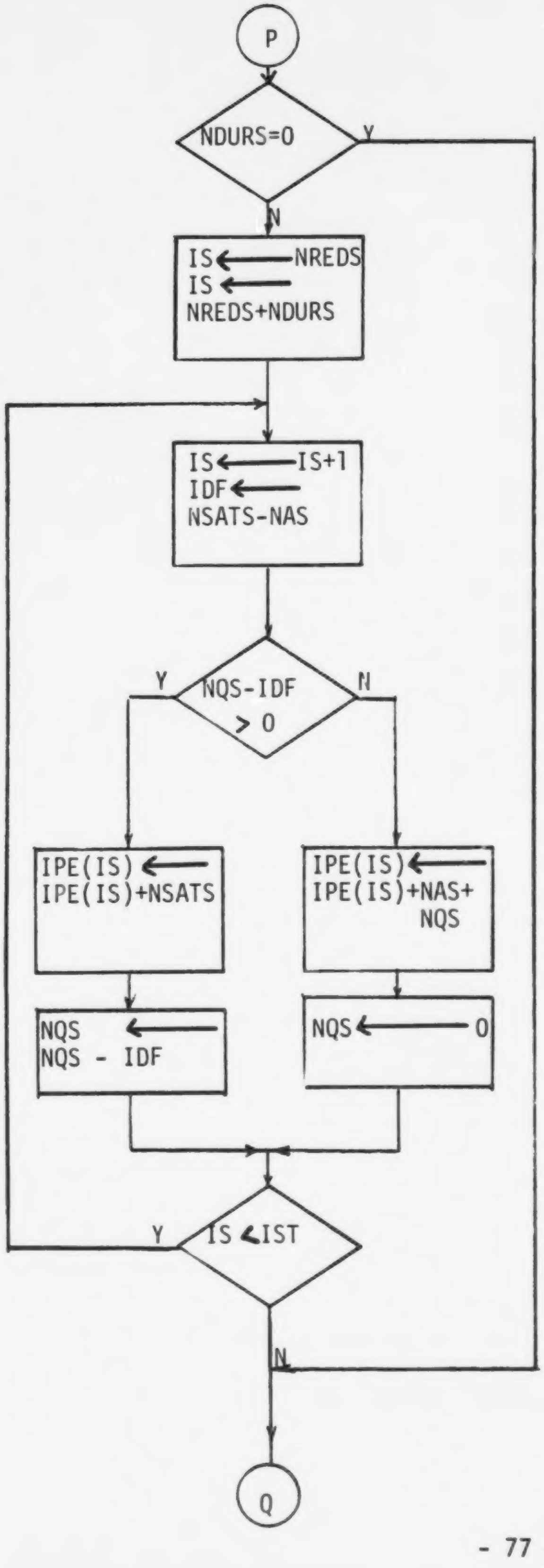
IDEALO


K
CALCULATE NDVRT, NVOL NVOLT, NSATT
I
IDXR = 0
Y
N
CALCULATE IPCNTR
IPCNTR ≤ 1
Y
N
CALCULATE NPCNTR NPCNTL IPCNTL, IPCNT
NREDR ← 0
I ← 0
M
I ← I+1
K = I
J ← LFLOW(IDXR,I,3)
J ≠ 0
Y
N
L
L
NREDR ← NREDR+ LFLOW(IDXR,I,2)/2)
I < SMAX
Y
M
N
CALCULATE NVOL, NVOLR NSATR, NDURR
IDXL+ IDXL2=0
Y
N
N
NREDL ← 0
K ← 0
KK ← 0
O

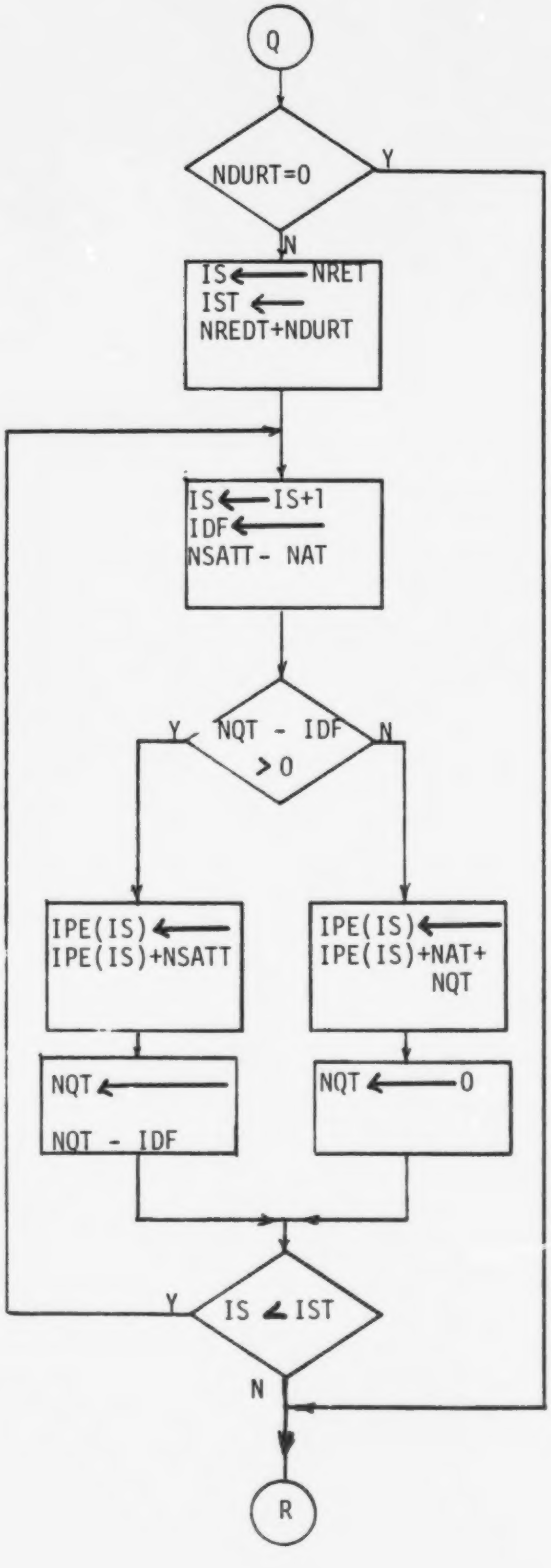
IDEALO


O
I ← 1
I:SMAX
I ← I+1
>
≤
IDXL2=0
Y
N
J ← LFLOW(IDXL2, I,3)
J ≠ 0
Y
K ← I
N
LFT ≠ 1 AND J+K = 0
Y
NREDL ← NREDL+ (LFLOW(IDXL2, I,1)/2)
N
LFT≠1
Y
N
JJ ← LFLOW(IDXL,I, 4)
JJ≠ 0
Y
KK=I
N
JJ+KK=0
Y
NREDL ← NREDL+ (LFLOW(IDXL, I,1)/2)
N
LFTL ← LFT+1
LFT1
2
1
COMPUTE
- NVOL
- NSATL
COMPUTE
- IPCNT,IPCNTL
- NVOLL,IPCNTR
- NDURL = NDURU
COMPUTE
- NSATL
- NVOLL
- NDURL,NDURU
N
NAT=NVOLT/1800
NAL=NVOLL/1800
NAR=NVOLR/1800
NAS=NVOLS/1800
NQT ← (NCYCS-NDURT)*NAT
NQL ← (NCYCS-NDURL)*NAL
NQR ← (NCYCS-NDURR)*NAR
NQS ← (NCYCS-NDURS)*NAS
P

IDEALO

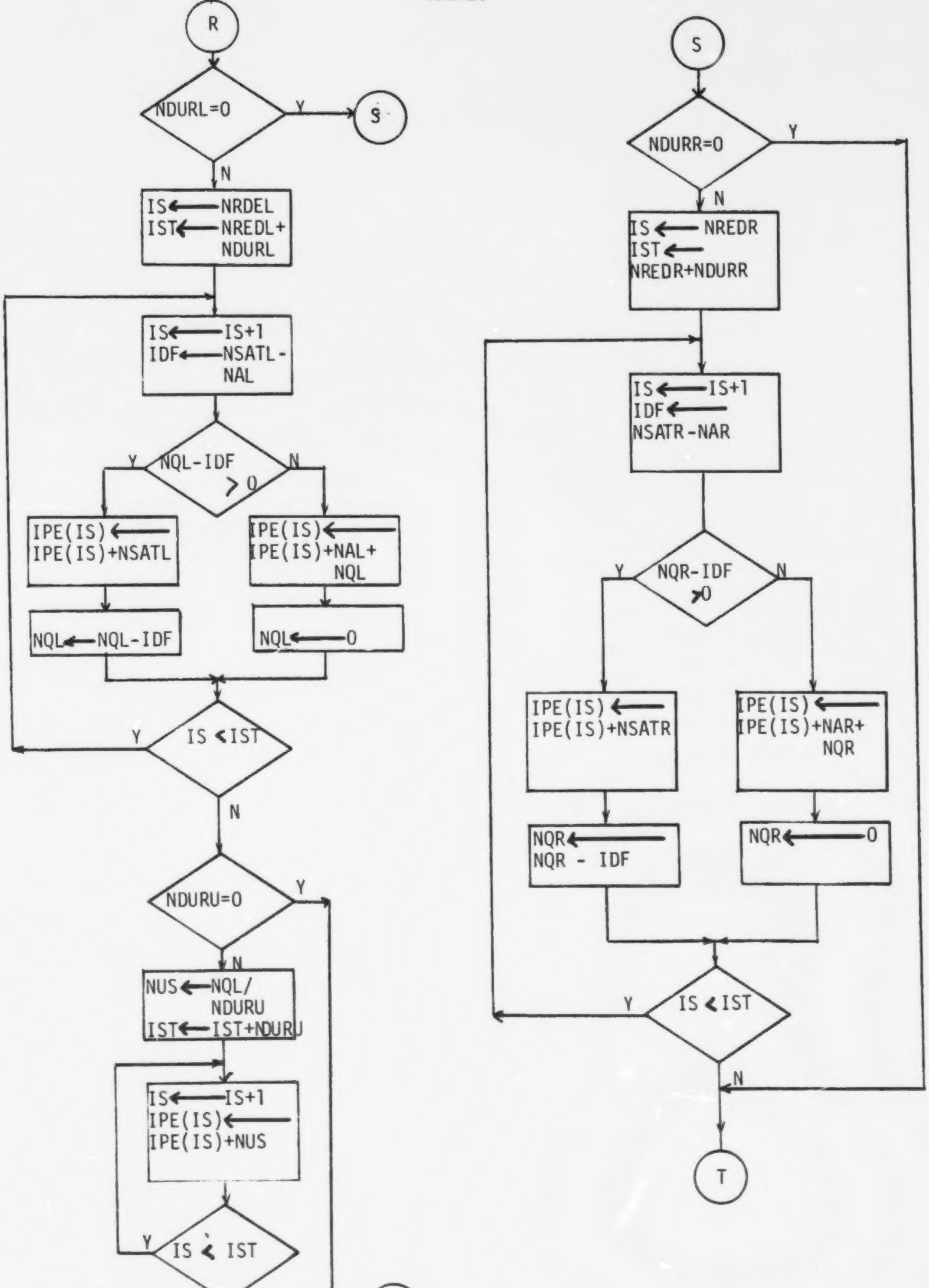


P
NDURS=0
Y
N
IS ← NREDS
IS ←
NREDS+NDURS
IS ← IS+1
IDF ←
NSATS-NAS
NQS-IDF
> 0
Y
N
IPE(IS) ←
IPE(IS)+NSATS
IPE(IS) ←
IPE(IS)+NAS+
NQS
NQS ←
NQS - IDF
NQS ← 0
IS < IST
Y
N
Q

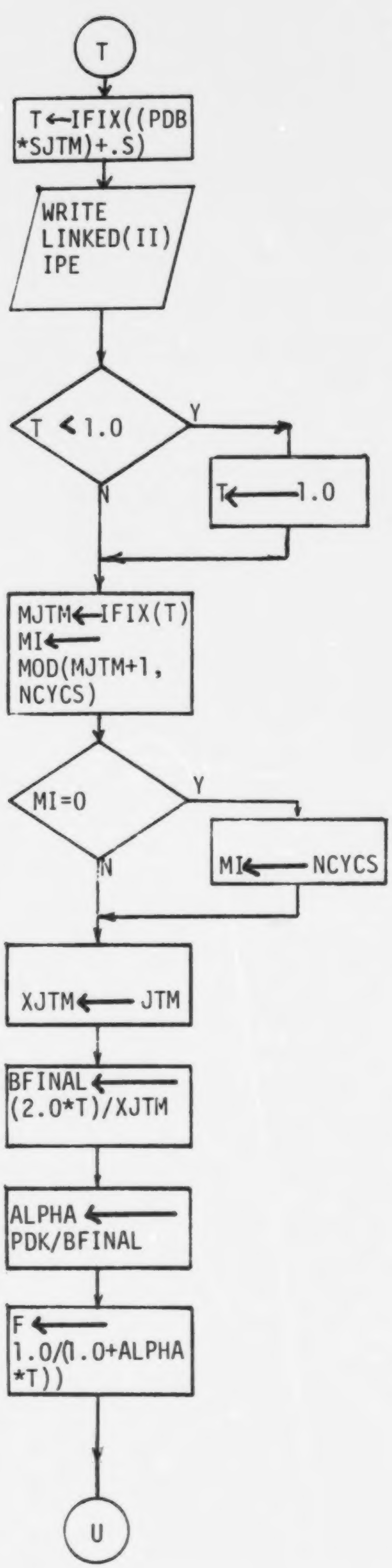


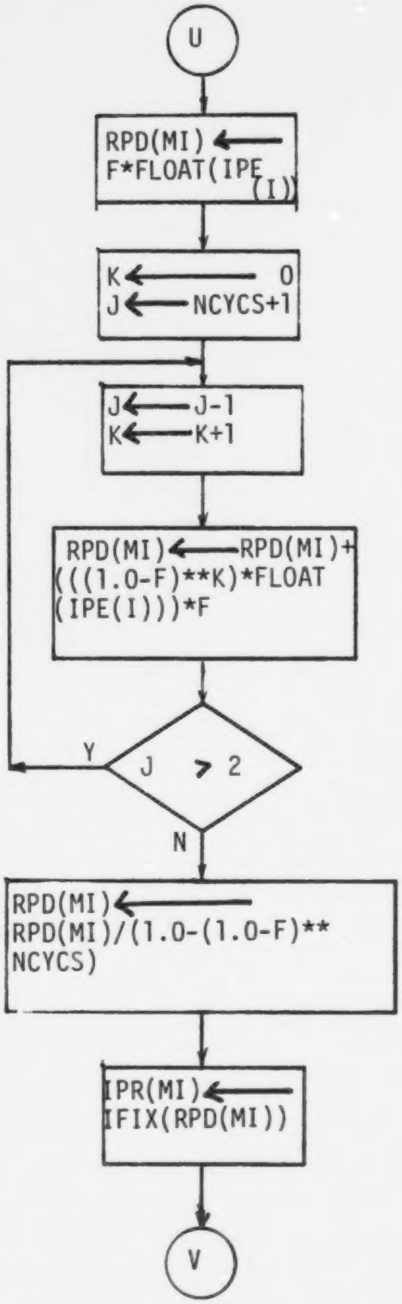
Q
NDURT=0
Y
N
IS ← NRET
IST ←
NREDT+NDURT
IS ← IS+1
IDF ←
NSATT- NAT
NQT - IDF
> 0
Y
N
IPE(IS) ←
IPE(IS)+NSATT
IPE(IS) ←
IPE(IS)+NAT+
NQT
NQT ←
NQT - IDF
NQT ← 0
IS < IST
Y
N
R

IDEALO

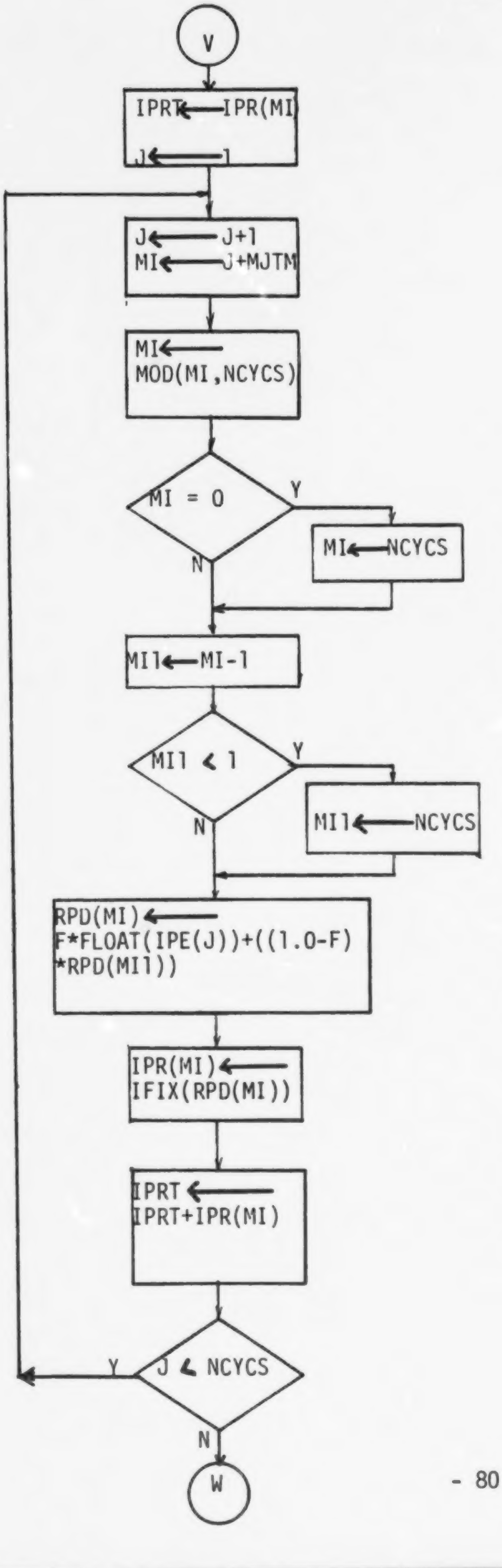

R
NDURL=0
Y
S
N
IS ← NRDEL
IST ← NREDL+ NDURL
IS ← IS+1
IDF ← NSATL-NAL
NQL-IDF > 0
Y
N
IPE(IS) ← IPE(IS)+NSATL
IPE(IS) ← IPE(IS)+NAL+ NQL
NQL ← NQL-IDF
NQL ← 0
IS < IST
Y
N
NDURU=0
Y
N
NUS ← NQL/ NDURU
IST ← IST+NDURU
IS ← IS+1
IPE(IS) ← IPE(IS)+NUS
IS < IST
Y
N
S
S
NDURR=0
Y
N
IS ← NREDR
IST ← NREDR+NDURR
IS ← IS+1
IDF ← NSATR-NAR
NQR-IDF > 0
Y
N
IPE(IS) ← IPE(IS)+NSATR
IPE(IS) ← IPE(IS)+NAR+ NQR
NQR ← NQR - IDF
NQR ← 0
IS < IST
Y
N
T

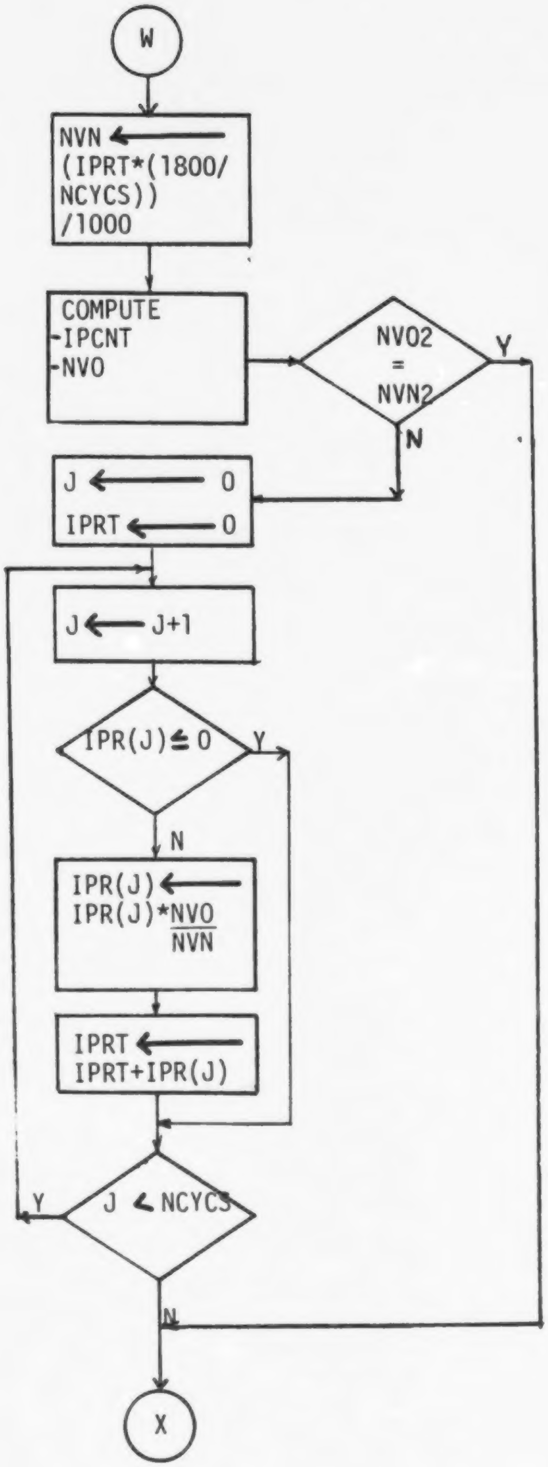
IDEALO


T
T←IFIX((PDB *SJTM)+.S)
WRITE LINKED(II) IPE
T < 1.0
Y
N
T←1.0
MJTM←IFIX(T) MI← MOD(MJTM+1, NCYCS)
MI=0
Y
N
MI←NCYCS
XJTM←JTM
BFINAL← (2.0*T)/XJTM
ALPHA← PDK/BFINAL
F← 1.0/(1.0+ALPHA *T))
U

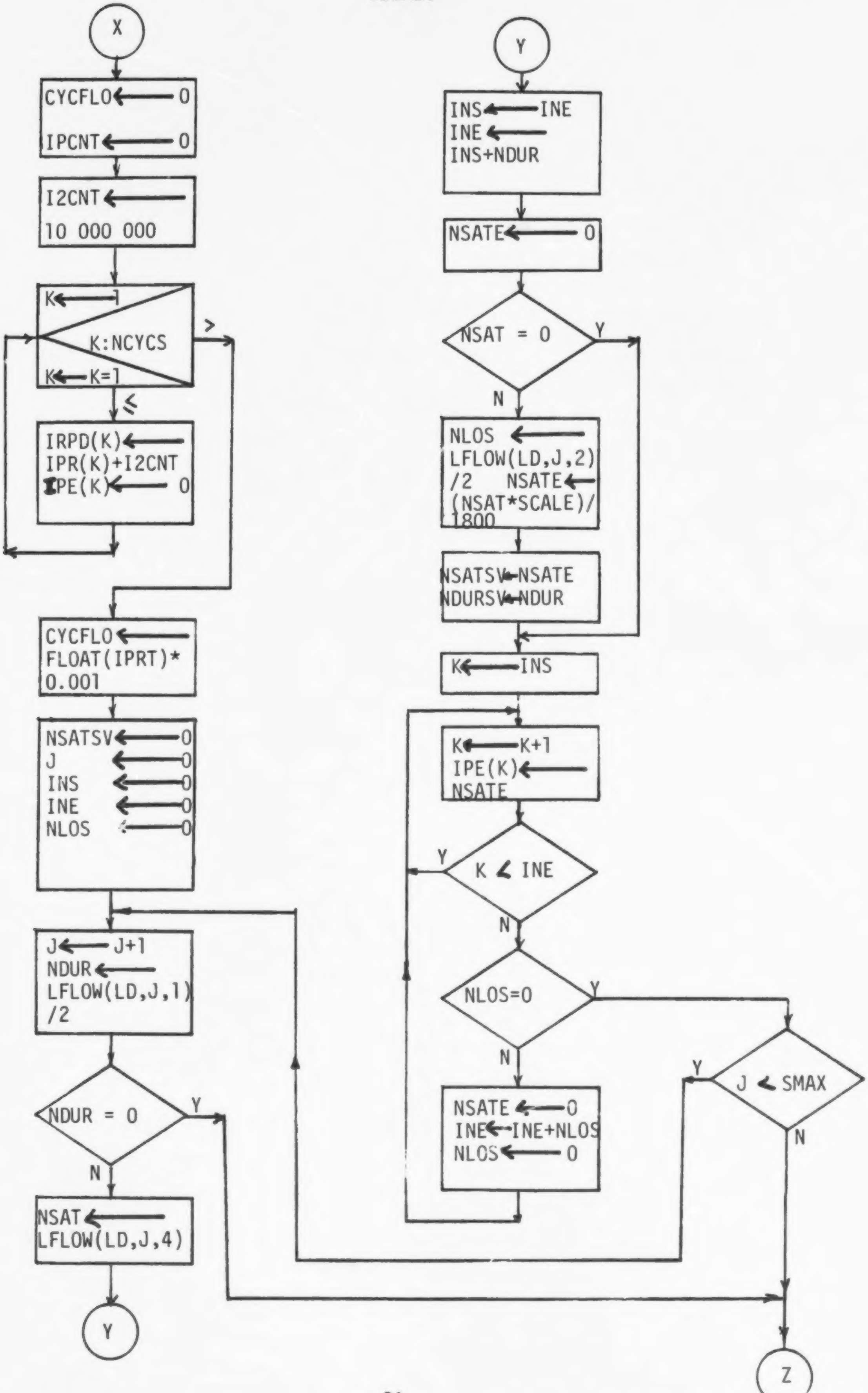

U
RPD(MI)← F*FLOAT(IPE(I))
K←0
J←NCYCS+1
J←J-1
K←K+1
RPD(MI)←RPD(MI)+ (((1.0-F)**K)*FLOAT (IPE(I)))*F
J > 2
Y
N
RPD(MI)← RPD(MI)/(1.0-(1.0-F)** NCYCS)
IPR(MI)← IFIX(RPD(MI))
V

IDEALO

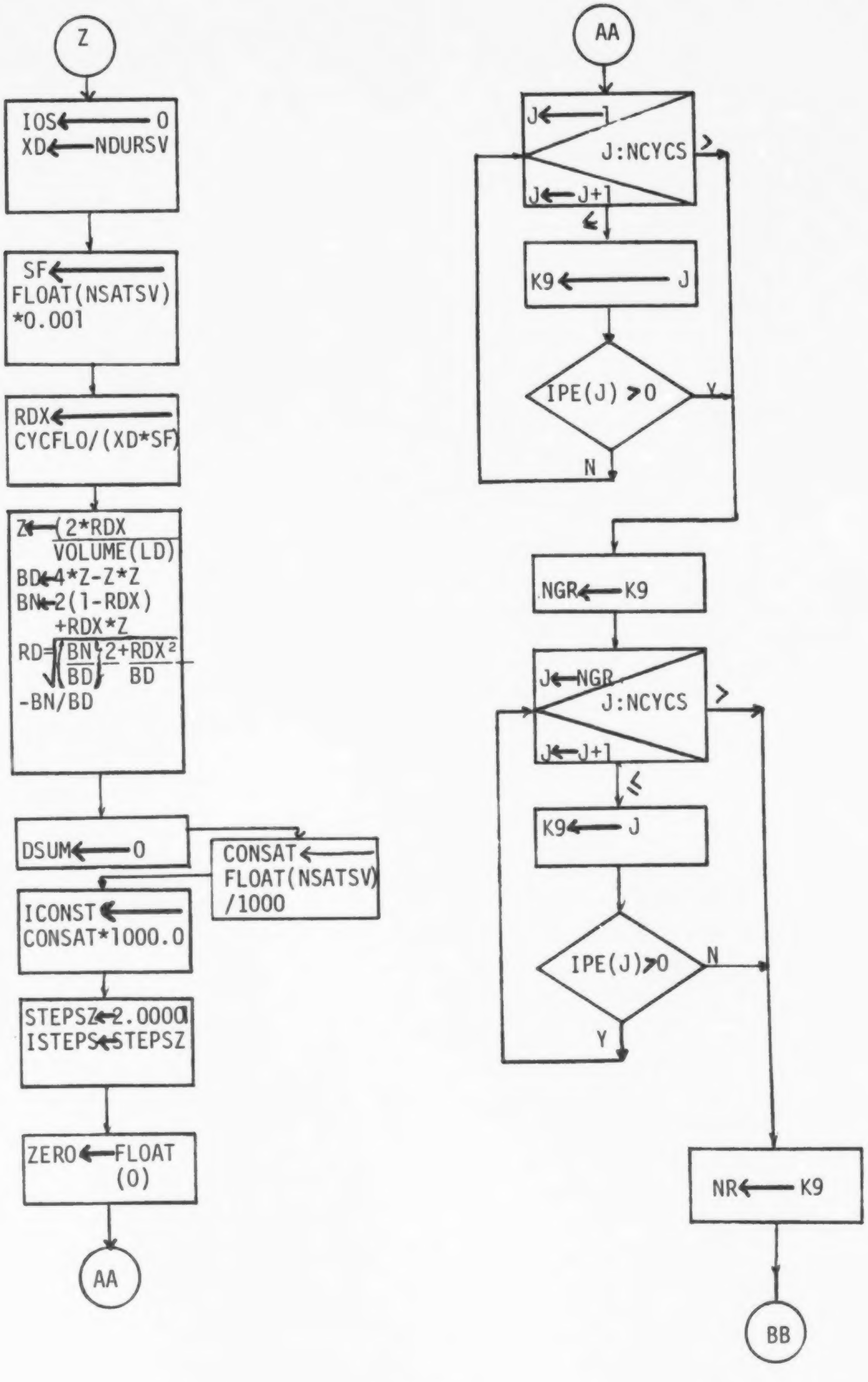

V
IPRT ← IPR(MI)
J ← 1
J ← J+1
MI ← J+MJTM
MI ←
MOD(MI,NCYCS)
MI = 0
Y
N
MI ← NCYCS
MI1 ← MI-1
MI1 < 1
Y
N
MI1 ← NCYCS
RPD(MI) ←
F*FLOAT(IPE(J))+((1.0-F)
*RPD(MI1))
IPR(MI) ←
IFIX(RPD(MI))
IPRT ←
IPRT+IPR(MI)
J < NCYCS
Y
N
W


W
NVN ←
(IPRT*(1800/
NCYCS))
/1000
COMPUTE
-IPCNT
-NVO
NVO2
=
NVN2
Y
N
J ← 0
IPRT ← 0
J ← J+1
IPR(J) ≤ 0
Y
N
IPR(J) ←
IPR(J)*NVO/NVN
IPRT ←
IPRT+IPR(J)
J < NCYCS
Y
N
X

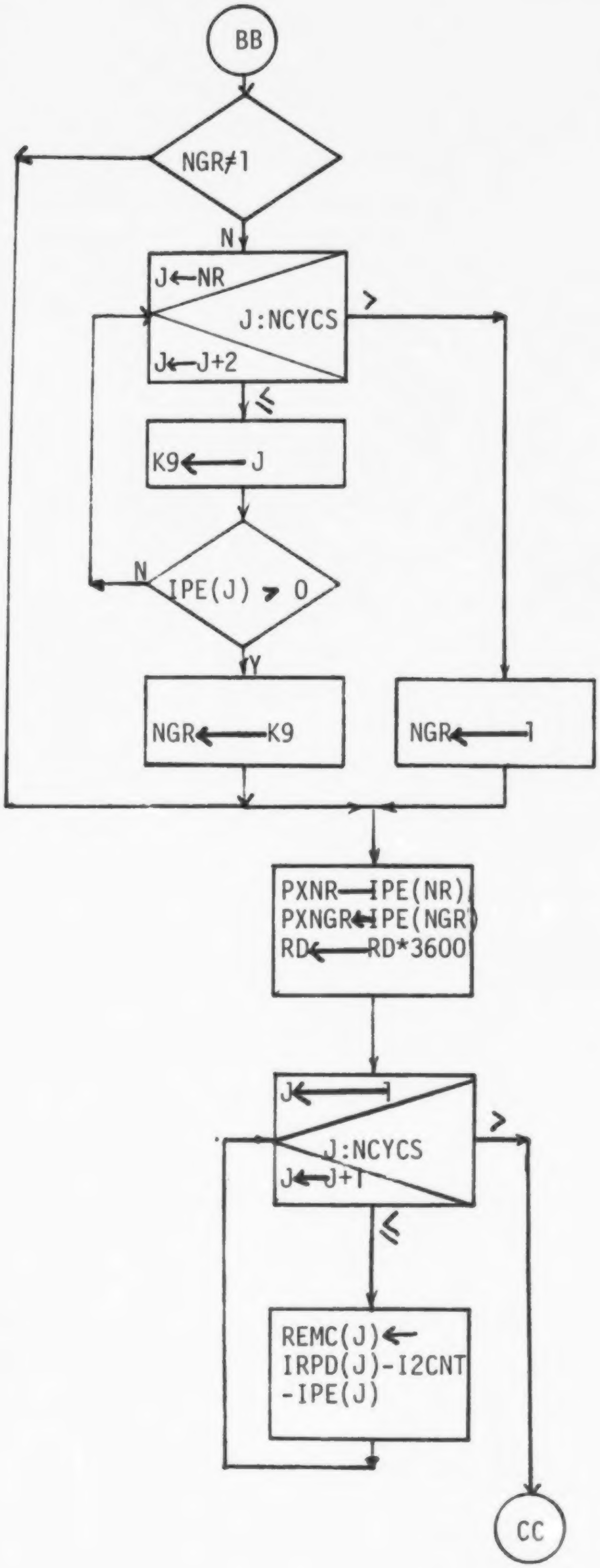
IDEALO


X
CYCFLO ← 0
IPCNT ← 0
I2CNT ← 10 000 000
K ← 1
K:NCYCS
K ← K=1
>
≤
IRPD(K) ← IPR(K)+I2CNT
IPE(K) ← 0
CYCFLO ← FLOAT(IPRT)*0.001
NSATSV ← 0
J ← 0
INS ← 0
INE ← 0
NLOS ← 0
J ← J+1
NDUR ← LFLOW(LD,J,1)/2
NDUR = 0
Y
N
NSAT ← LFLOW(LD,J,4)
Y
Y
INS ← INE
INE ← INS+NDUR
NSATE ← 0
NSAT = 0
Y
N
NLOS ← LFLOW(LD,J,2)/2
NSATE ← (NSAT*SCALE)/1800
NSATSV ← NSATE
NDURSV ← NDUR
K ← INS
K ← K+1
IPE(K) ← NSATE
K ∠ INE
Y
N
NLOS=0
Y
N
NSATE ← 0
INE ← INE+NLOS
NLOS ← 0
J ∠ SMAX
Y
N
Z

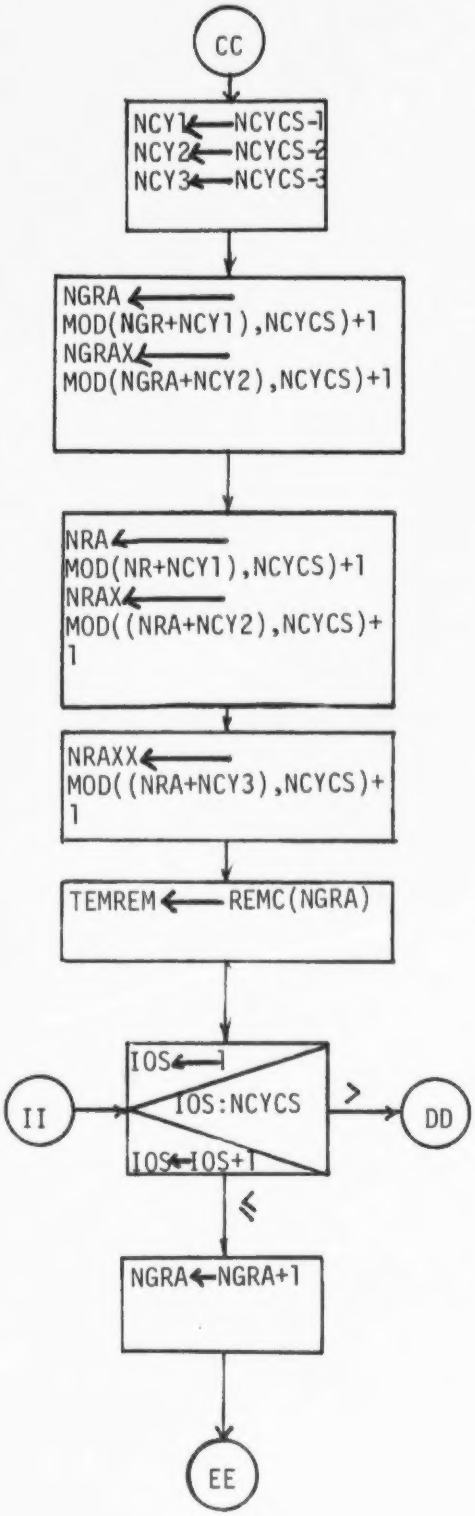
IDEALO


Z
IOS ← 0
XD ← NDURSV
SF ← FLOAT(NSATSV) *0.001
RDX ← CYCFLO/(XD*SF)
Z ← (2*RDX / VOLUME(LD))
BD ← 4*Z-Z*Z
BN ← 2(1-RDX) +RDX*Z
RD = √((BN/BD)^2 + RDX^2/BD) -BN/BD
DSUM ← 0
CONSAT ← FLOAT(NSATSV) /1000
ICONST ← CONSAT*1000.0
STEPSZ ← 2.0000
ISTEPS ← STEPSZ
ZERO ← FLOAT (0)
AA
AA
J ← 1
J:NCYCS
J ← J+1
>
≤
K9 ← J
IPE(J) > 0
Y
N
NGR ← K9
J ← NGR
J:NCYCS
J ← J+1
>
≤
K9 ← J
IPE(J) > 0
N
Y
NR ← K9
BB

IDEALO

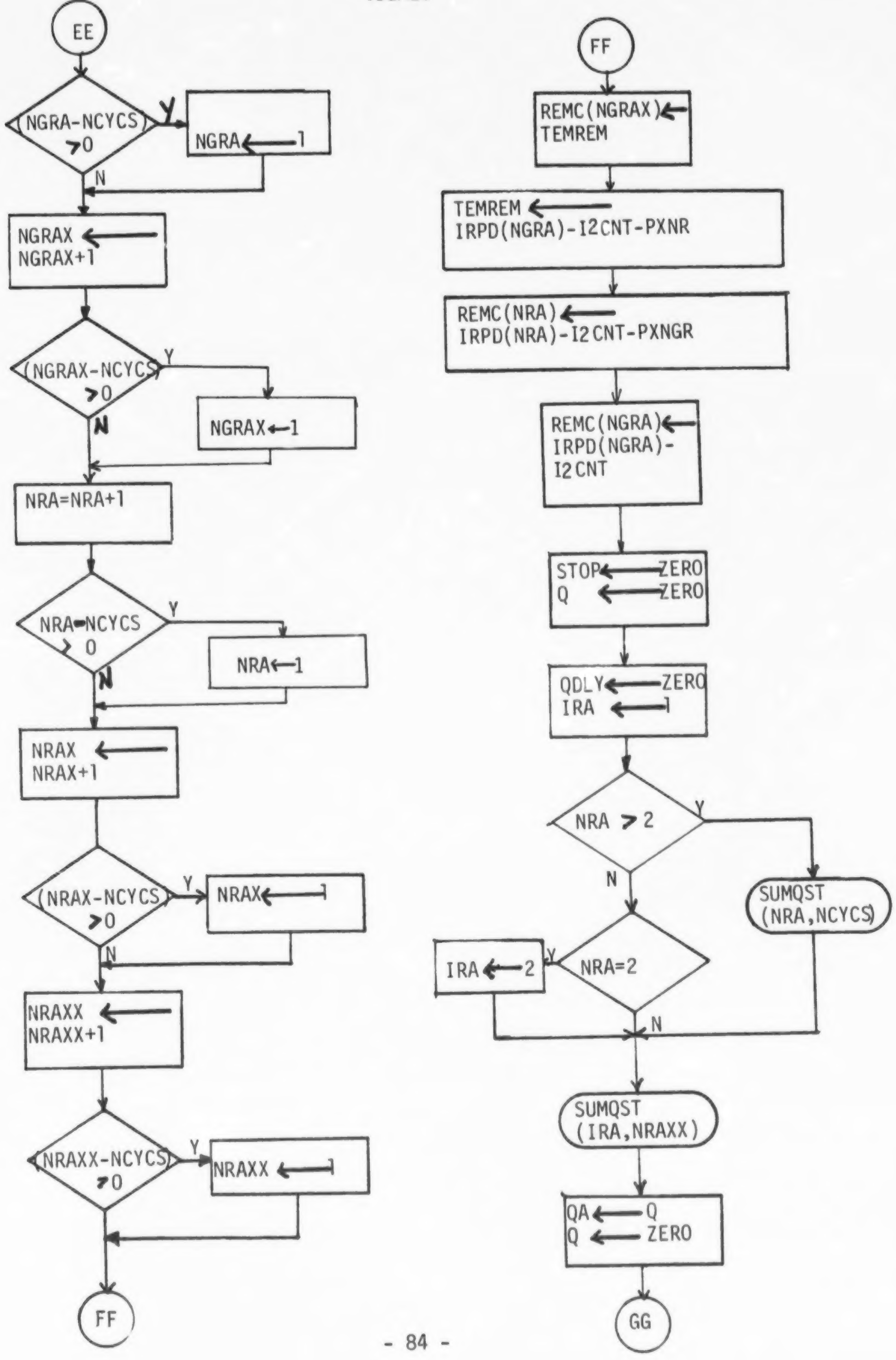


BB
NGR≠1
N
J←NR
J:NCYCS
J←J+2
>
≤
K9←J
IPE(J) > 0
N
Y
NGR←K9
NGR←1
PXNR←IPE(NR)
PXNGR←IPE(NGR)
RD←RD*3600
J←1
J:NCYCS
J←J+1
>
≤
REMC(J)←
IRPD(J)-I2CNT
-IPE(J)
CC

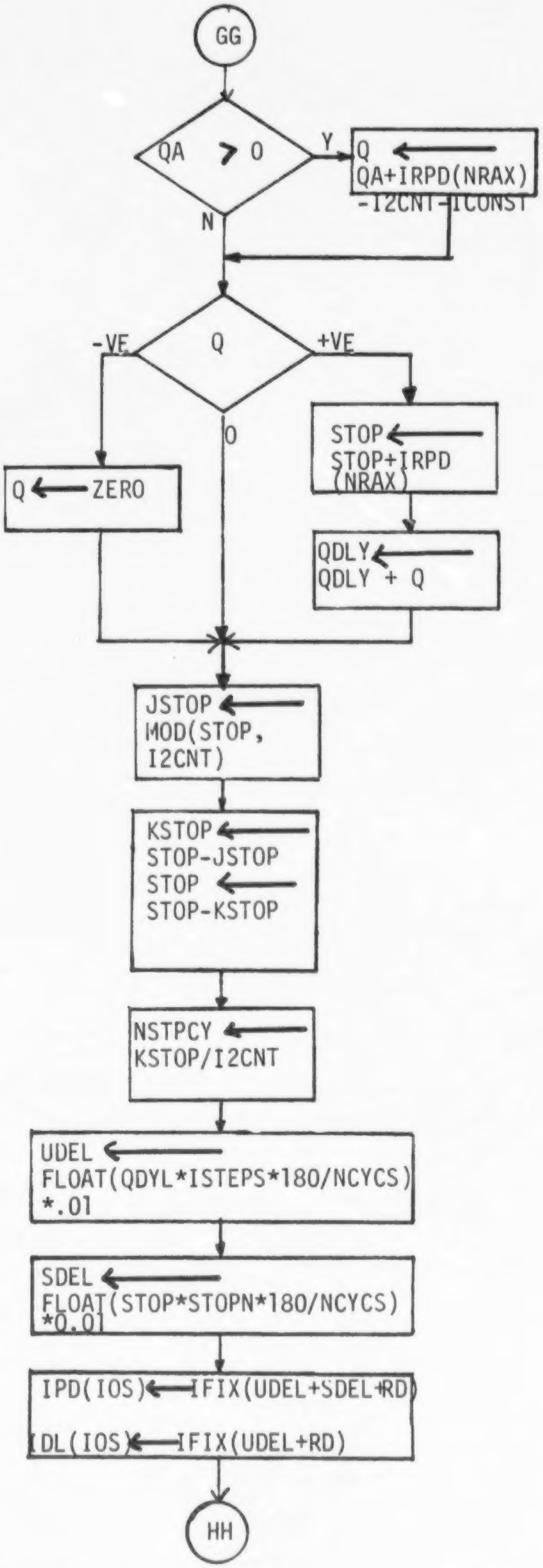


CC
NCY1←NCYCS-1
NCY2←NCYCS-2
NCY3←NCYCS-3
NGRA←
MOD(NGR+NCY1),NCYCS)+1
NGRAX←
MOD(NGRA+NCY2),NCYCS)+1
NRA←
MOD(NR+NCY1),NCYCS)+1
NRAX←
MOD((NRA+NCY2),NCYCS)+
1
NRAXX←
MOD((NRA+NCY3),NCYCS)+
1
TEMREM←REMC(NGRA)
II
IOS←1
IOS:NCYCS
IOS←IOS+1
>
DD
≤
NGRA←NGRA+1
EE

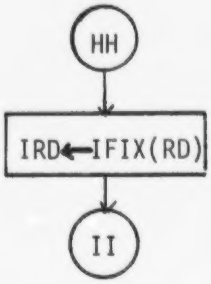
IDEALO


EE
(NGRA-NCYCS) >0
Y
N
NGRA ← 1
NGRAX ← NGRAX+1
(NGRAX-NCYCS) >0
Y
N
NGRAX ← 1
NRA=NRA+1
NRA-NCYCS > 0
Y
N
NRA ← 1
NRAX ← NRAX+1
(NRAX-NCYCS) >0
Y
N
NRAX ← 1
NRAXX ← NRAXX+1
(NRAXX-NCYCS) >0
Y
NRAXX ← 1
FF
FF
REMC(NGRAX) ← TEMREM
TEMREM ← IRPD(NGRA)-I2CNT-PXNR
REMC(NRA) ← IRPD(NRA)-I2CNT-PXNGR
REMC(NGRA) ← IRPD(NGRA)-I2CNT
STOP ← ZERO
Q ← ZERO
QDLY ← ZERO
IRA ← 1
NRA > 2
Y
N
SUMQST (NRA,NCYCS)
NRA=2
Y
N
IRA ← 2
SUMQST (IRA,NRAXX)
QA ← Q
Q ← ZERO
GG

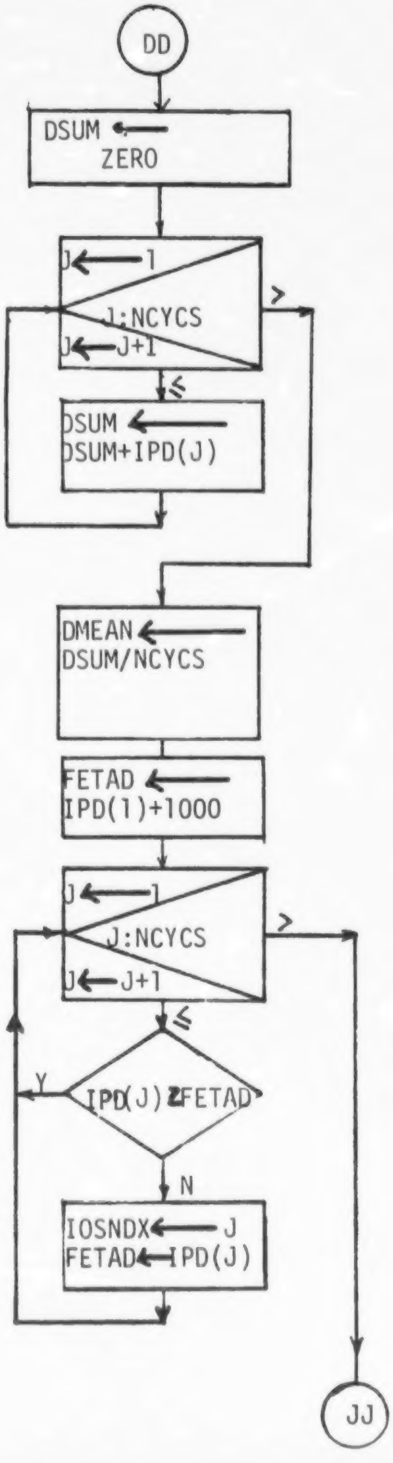
IDEALO



GG
QA > 0
Y
N
Q ← QA+IRPD(NRAX) -I2CNT-ICONST
Q
-VE
+VE
0
Q ← ZERO
STOP ← STOP+IRPD (NRAX)
QDLY ← QDLY + Q
JSTOP ← MOD(STOP, I2CNT)
KSTOP ← STOP-JSTOP
STOP ← STOP-KSTOP
NSTPCY ← KSTOP/I2CNT
UDEL ← FLOAT(QDYL*ISTEPS*180/NCYCS) *.01
SDEL ← FLOAT(STOP*STOPN*180/NCYCS) *0.01
IPD(IOS) ← IFIX(UDEL+SDEL+RD)
IDL(IOS) ← IFIX(UDEL+RD)
HH

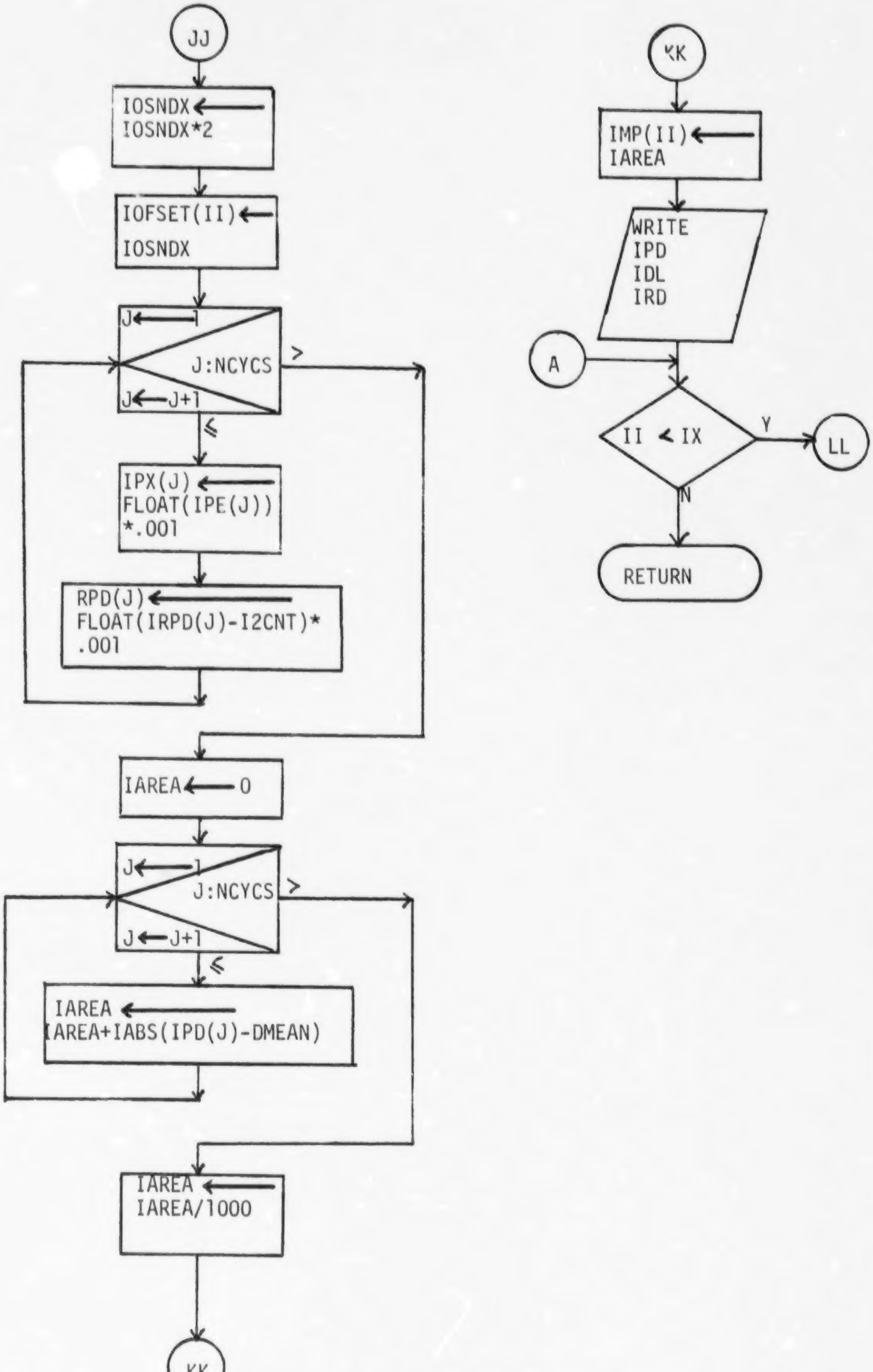


HH
IRD ← IFIX(RD)
II

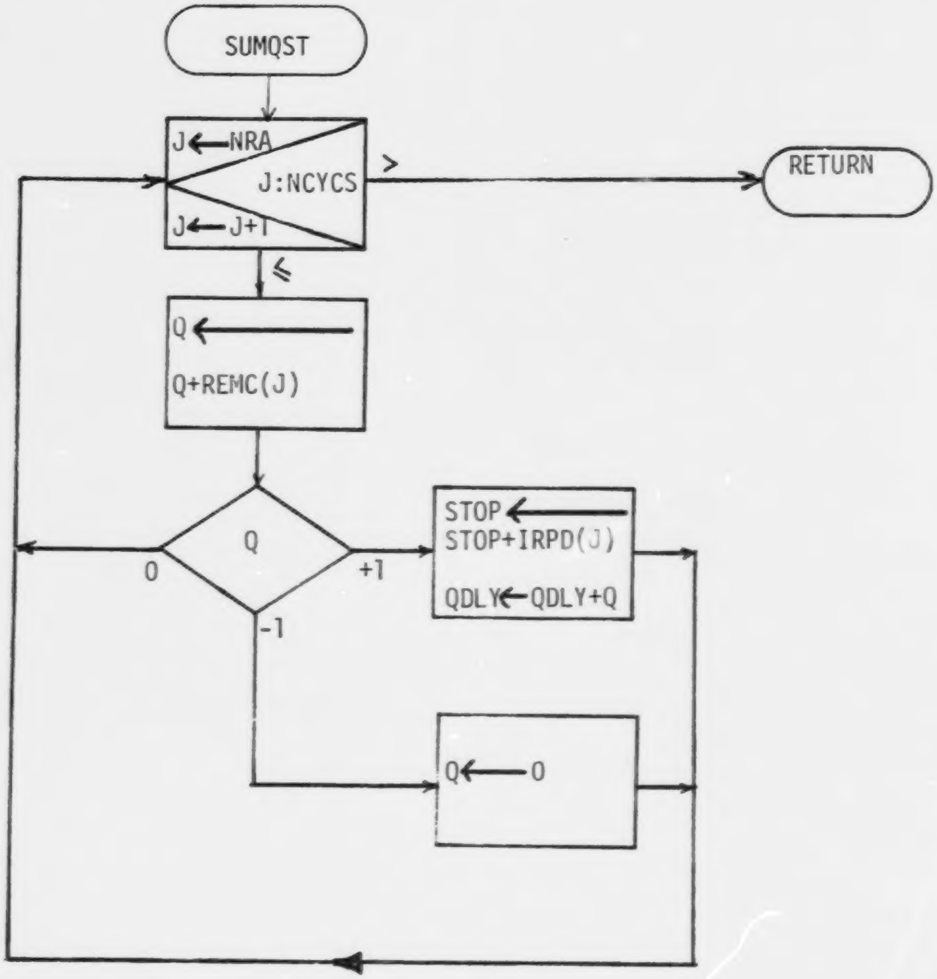


DD
DSUM ← ZERO
J ← 1
J:NCYCS
J ← J+1
>
≤
DSUM ← DSUM+IPD(J)
DMEAN ← DSUM/NCYCS
FETAD ← IPD(1)+1000
J ← 1
J:NCYCS
J ← J+1
>
≤
IPD(J) ≥ FETAD
Y
N
IOSNDX ← J
FETAD ← IPD(J)
JJ

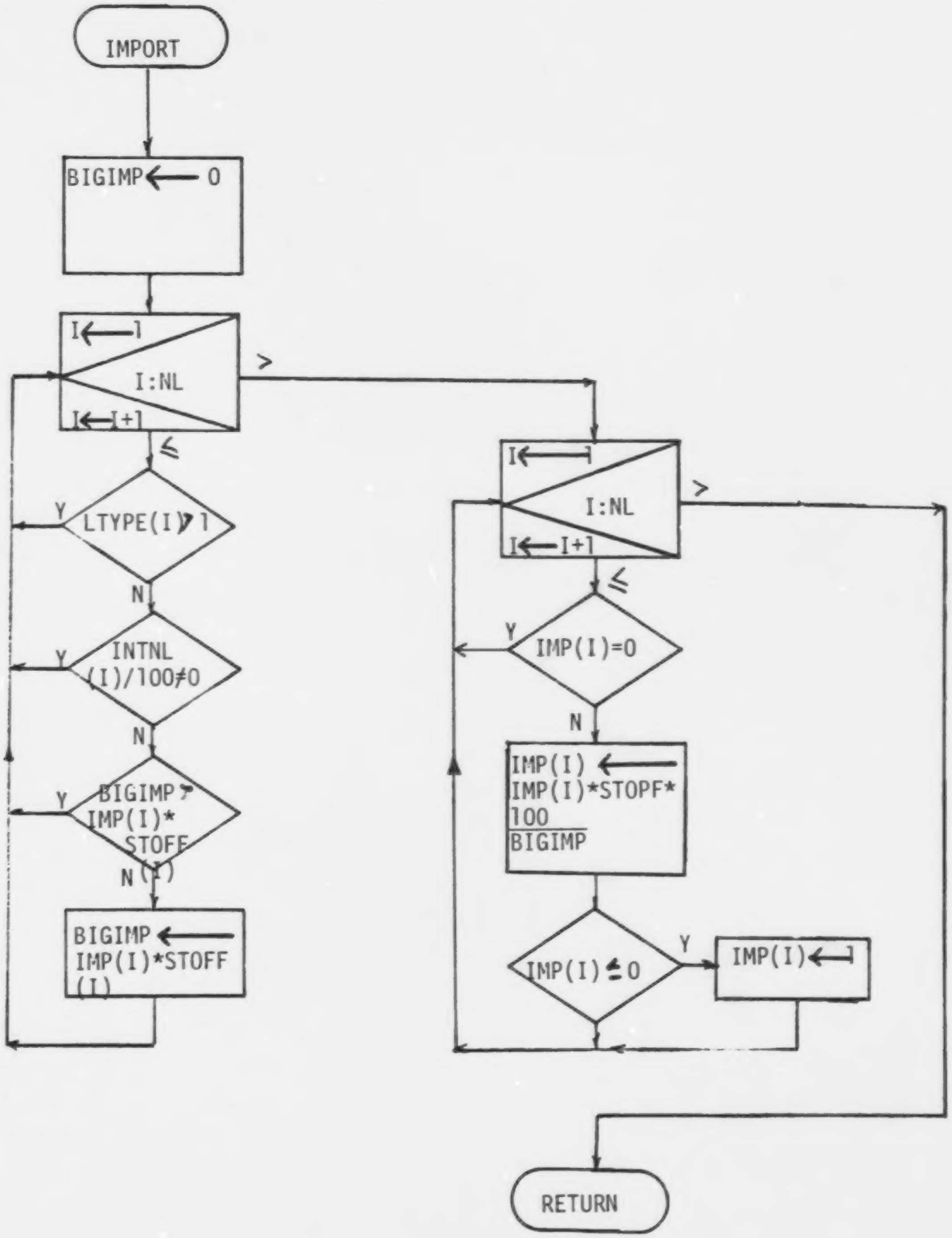
IDEALO


JJ
IOSNDX ←
IOSNDX*2
IOFSET(II) ←
IOSNDX
J ← 1
J:NCYCS
J ← J+1
>
≤
IPX(J) ←
FLOAT(IPE(J))
*.001
RPD(J) ←
FLOAT(IRPD(J)-I2CNT)*
.001
IAREA ← 0
J ← 1
J:NCYCS
J ← J+1
>
≤
IAREA ←
IAREA+IABS(IPD(J)-DMEAN)
IAREA ←
IAREA/1000
KK
KK
IMP(II) ←
IAREA
WRITE
IPD
IDL
IRD
A
II < IX
Y
N
LL
RETURN

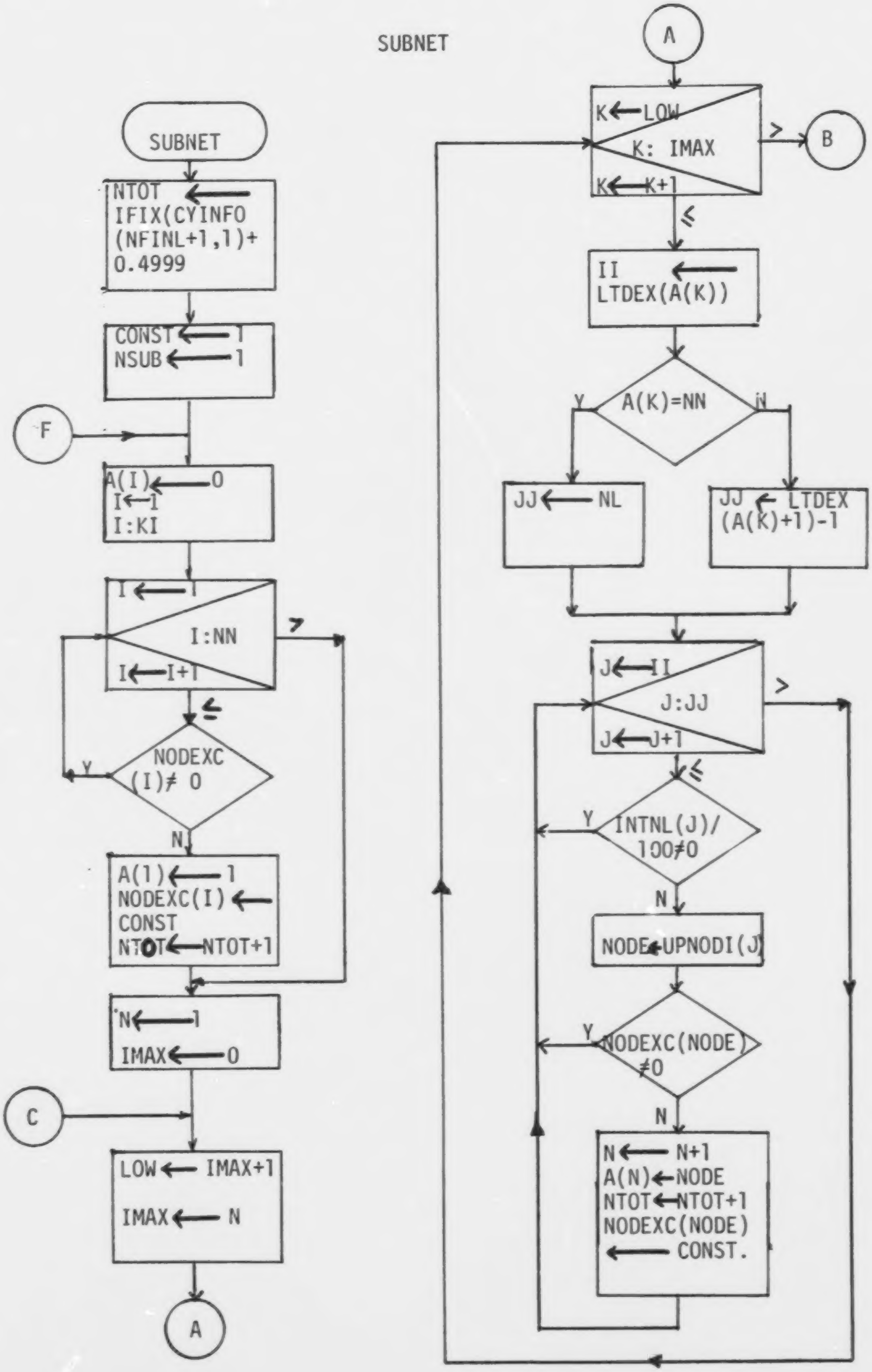
SUMQST


SUMQST
J ← NRA
J:NCYCS
J ← J+1
>
RETURN
≤
Q ←
Q+REMC(J)
Q
0
+1
-1
STOP ←
STOP+IRPD(J)
QDLY ← QDLY+Q
Q ← 0

IMPORT

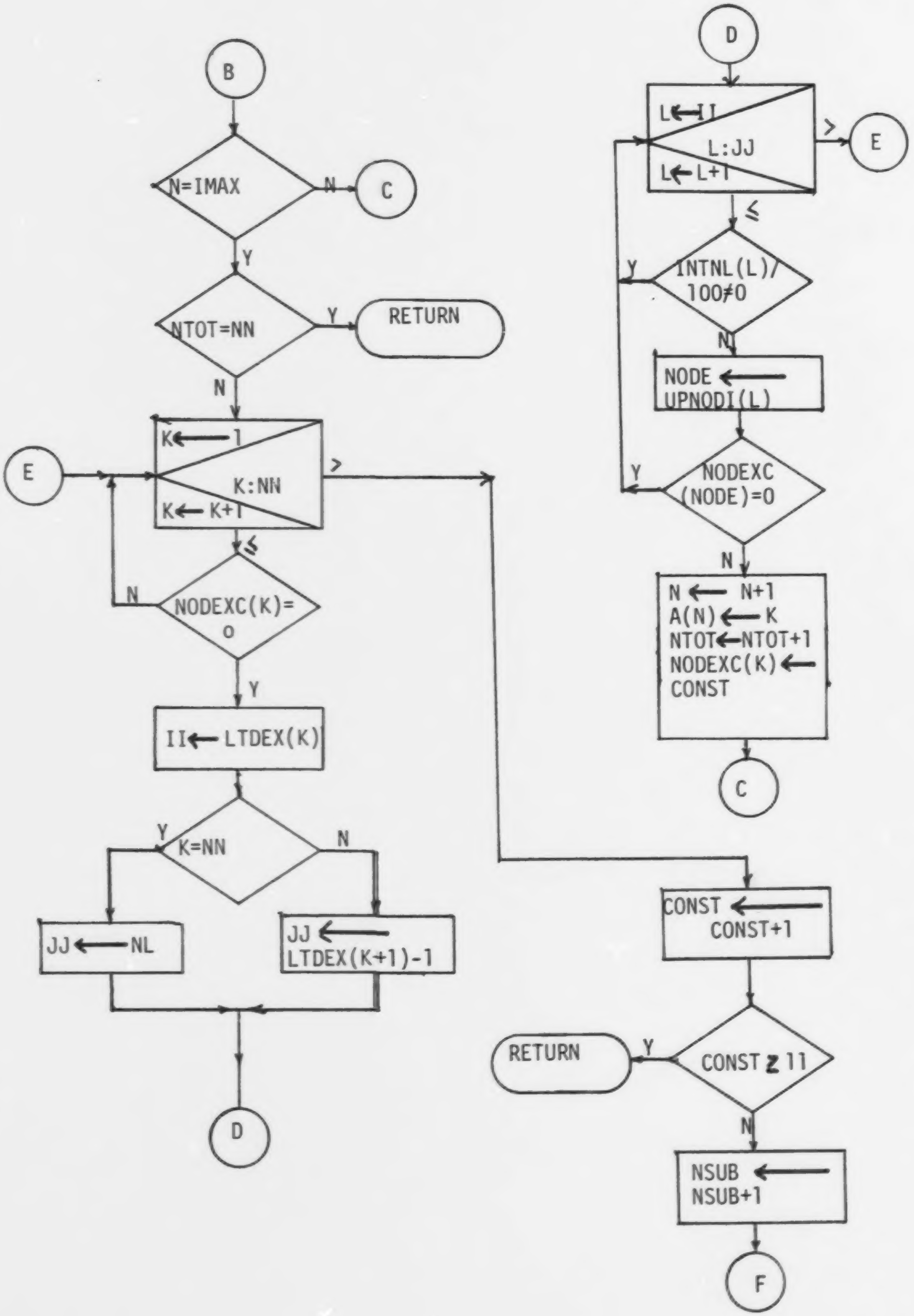

IMPORT
BIGIMP ← 0
I ← 1
I:NL
I ← I+1
>
≤
Y
LTYPE(I) > 1
N
Y
INTNL (I)/100≠0
N
Y
BIGIMP > IMP(I)* STOFF (I)
N
BIGIMP ← IMP(I)*STOFF (I)
I ← 1
I:NL
I ← I+1
>
≤
Y
IMP(I)=0
N
IMP(I) ← IMP(I)*STOFF* 100 / BIGIMP
IMP(I) ≤ 0
Y
IMP(I) ← 1
RETURN

SUBNET



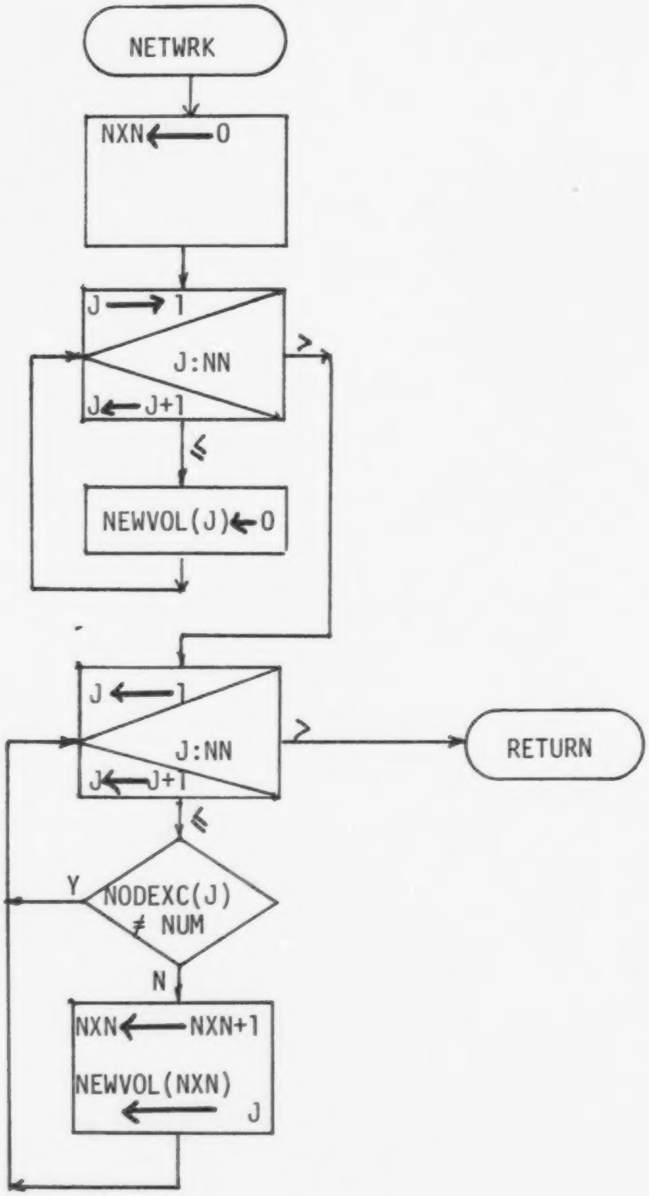
SUBNET
NTOT ← IFIX(CYINFO (NFINL+1,1)+ 0.4999
CONST ← 1
NSUB ← 1
F
A(I) ← 0
I ← 1
I:KI
I ← 1
I:NN
I ← I+1
>
≤
NODEXC (I)≠ 0
Y
N
A(I) ← 1
NODEXC(I) ← CONST
NTOT ← NTOT+1
N ← 1
IMAX ← 0
C
LOW ← IMAX+1
IMAX ← N
A
A
K ← LOW
K: IMAX
K ← K+1
>
B
≤
II ← LTDEX(A(K))
A(K)=NN
Y
N
JJ ← NL
JJ ← LTDEX (A(K)+1)-1
J ← II
J:JJ
J ← J+1
>
≤
INTNL(J)/ 100≠0
Y
N
NODE ← UPNODI(J)
NODEXC(NODE) ≠0
Y
N
N ← N+1
A(N) ← NODE
NTOT ← NTOT+1
NODEXC(NODE) ← CONST.

SUBNET

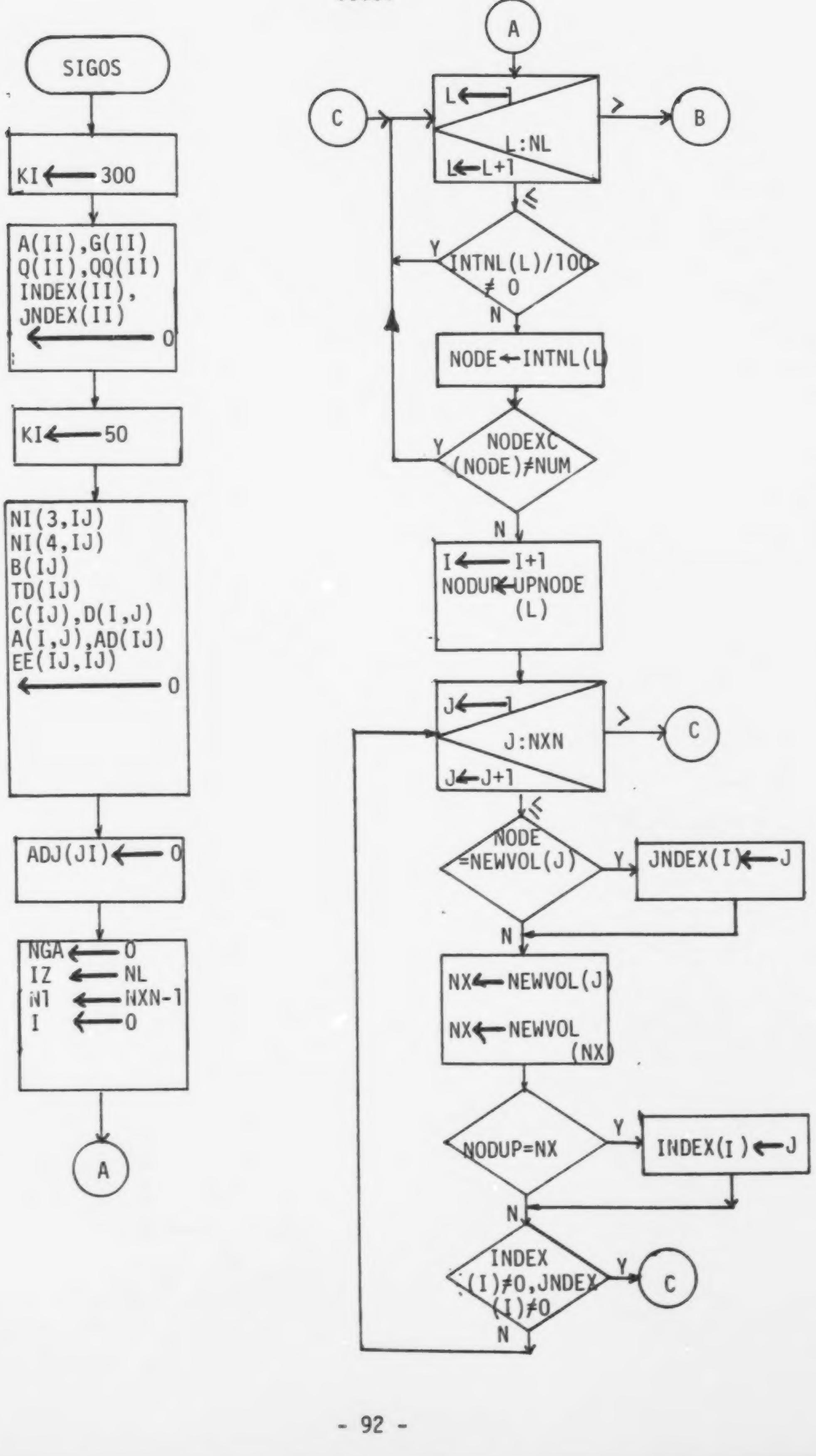


B
N=IMAX
N
C
Y
NTOT=NN
Y
RETURN
N
E
K←1
K:NN
K←K+1
>
≤
N
NODEXC(K)=
o
Y
II← LTDEX(K)
Y
K=NN
N
JJ←NL
JJ←
LTDEX(K+1)-1
D
D
L←II
L:JJ
L←L+1
>
E
≤
Y
INTNL(L)/
100≠0
N
NODE ←
UPNODI(L)
Y
NODEXC
(NODE)=0
N
N← N+1
A(N)← K
NTOT←NTOT+1
NODEXC(K)←
CONST
C
CONST ←
CONST+1
RETURN
Y
CONST ≥ 11
N
NSUB ←
NSUB+1
F

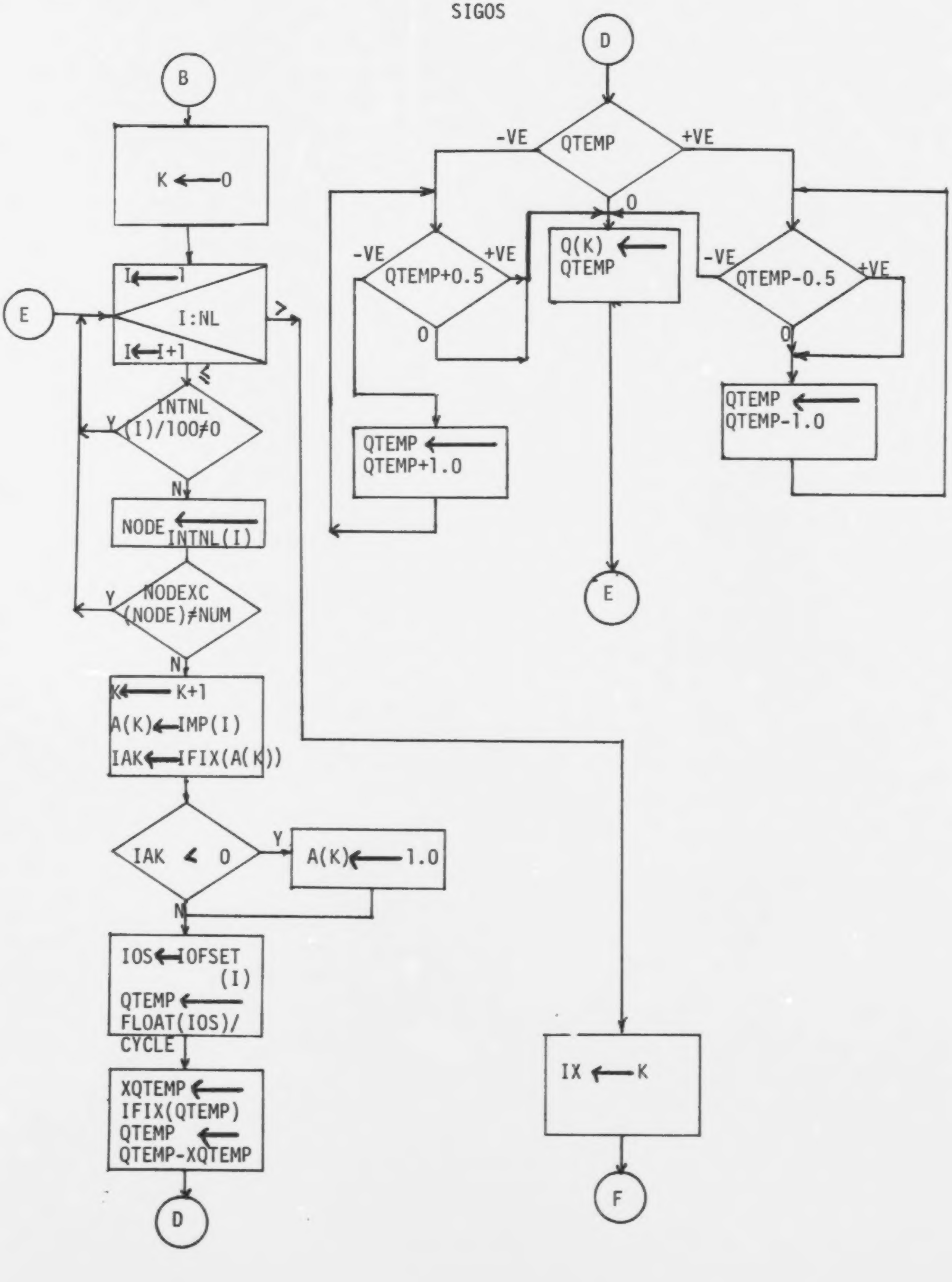
NETWRK


NETWRK
NXN ← 0
J → 1
J:NN
J ← J+1
>
≤
NEWVOL(J) ← 0
J ← 1
J:NN
J ← J+1
>
RETURN
≤
Y
NODEXC(J) ≠ NUM
N
NXN ← NXN+1
NEWVOL(NXN) ← J

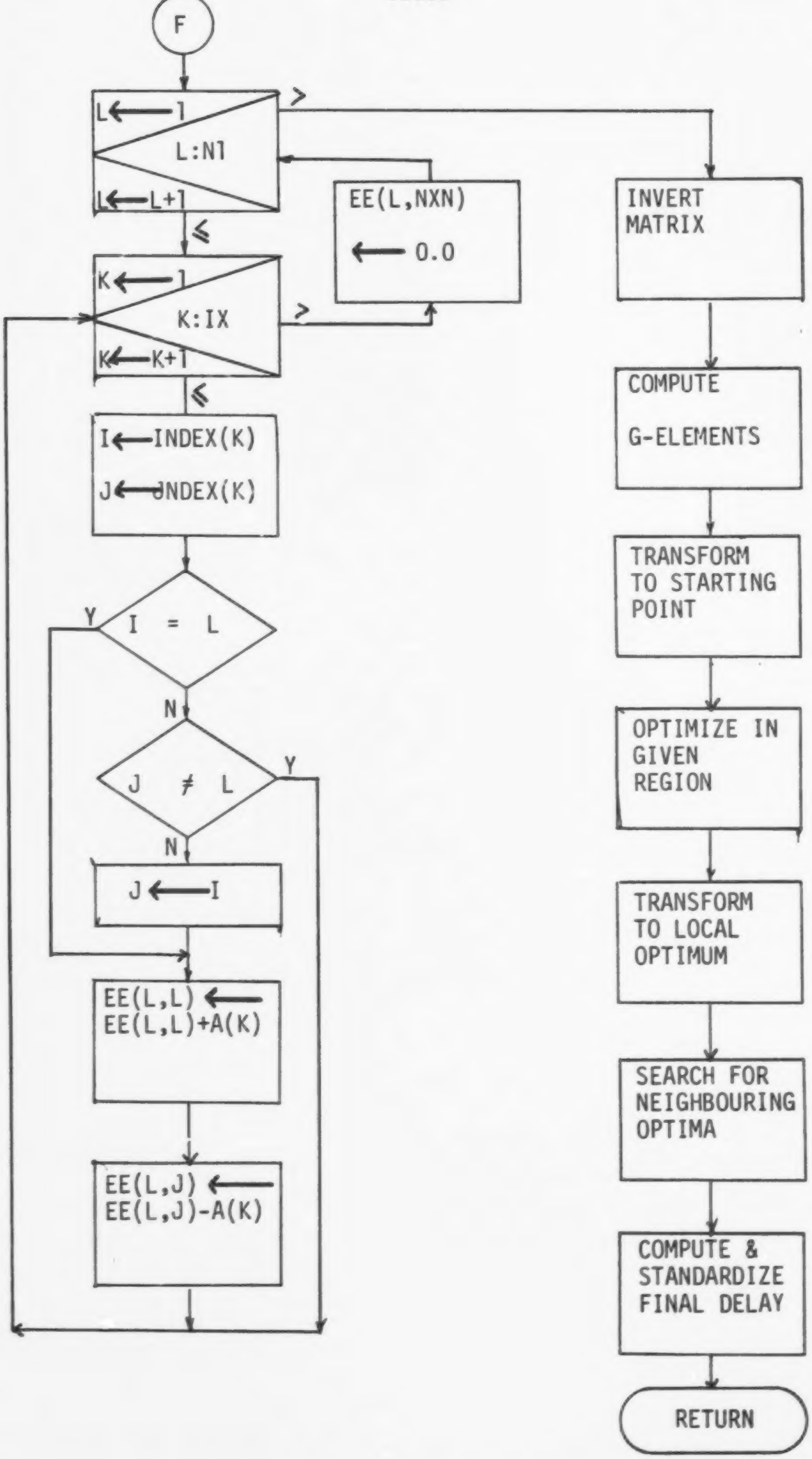
SIGOS


SIGOS
KI ⟵ 300
A(II),G(II)
Q(II),QQ(II)
INDEX(II),
JNDEX(II)
⟵ 0
KI ⟵ 50
NI(3,IJ)
NI(4,IJ)
B(IJ)
TD(IJ)
C(IJ),D(I,J)
A(I,J),AD(IJ)
EE(IJ,IJ)
⟵ 0
ADJ(JI) ⟵ 0
NGA ⟵ 0
IZ ⟵ NL
N1 ⟵ NXN-1
I ⟵ 0
A
A
C
L ⟵ 1
L:NL
L ⟵ L+1
>
B
≤
Y
INTNL(L)/100
≠ 0
N
NODE ⟵ INTNL(L)
Y
NODEXC
(NODE)≠NUM
N
I ⟵ I+1
NODUP ⟵ UPNODE
(L)
J ⟵ 1
J:NXN
J ⟵ J+1
>
C
≤
NODE
=NEWVOL(J)
Y
JNDEX(I) ⟵ J
N
NX ⟵ NEWVOL(J)
NX ⟵ NEWVOL
(NX)
NODUP=NX
Y
INDEX(I) ⟵ J
N
INDEX
(I)≠0,JNDEX
(I)≠0
Y
C
N

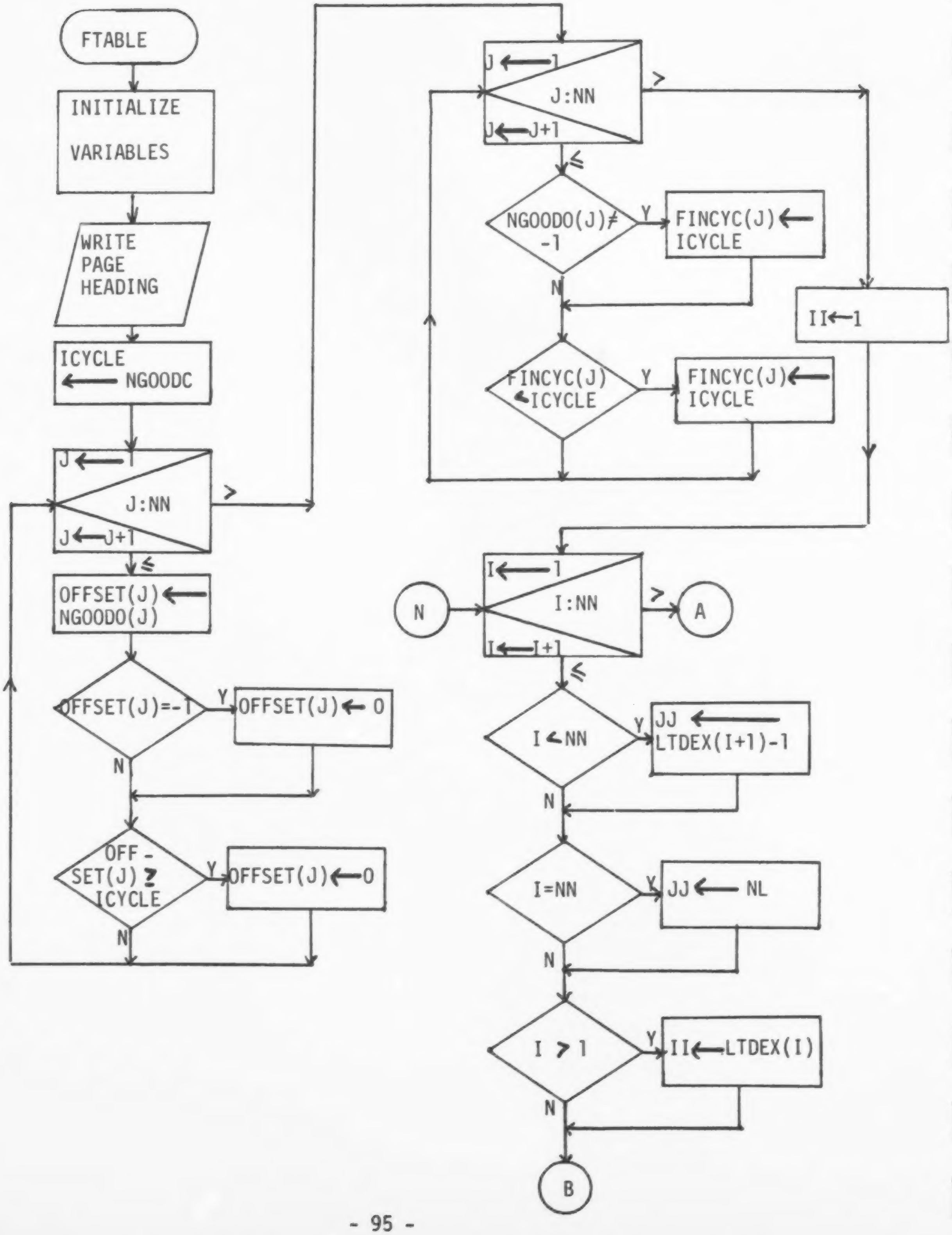
SIGOS


B
K ← 0
E
I ← 1
I:NL
I ← I+1
>
≤
INTNL (I)/100≠0
Y
N
NODE ← INTNL(I)
NODEXC (NODE)≠NUM
Y
N
K ← K+1
A(K) ← IMP(I)
IAK ← IFIX(A(K))
IAK < 0
Y
A(K) ← 1.0
N
IOS ← IOFSET (I)
QTEMP ← FLOAT(IOS)/ CYCLE
XQTEMP ← IFIX(QTEMP)
QTEMP ← QTEMP-XQTEMP
D
D
QTEMP
-VE
+VE
0
QTEMP+0.5
-VE
+VE
0
Q(K) ← QTEMP
QTEMP-0.5
-VE
+VE
0
QTEMP ← QTEMP+1.0
QTEMP ← QTEMP-1.0
E
IX ← K
F

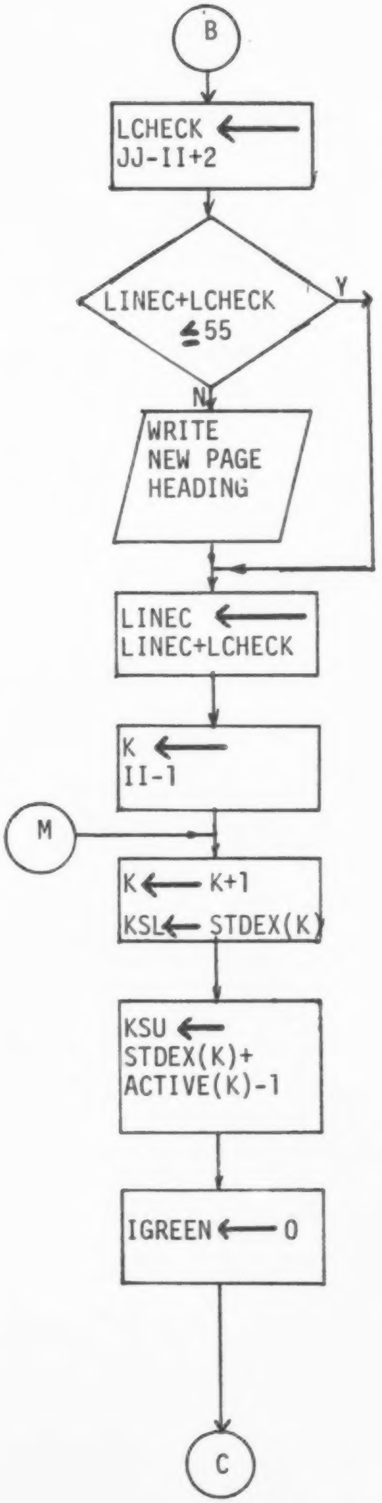
SIGOS

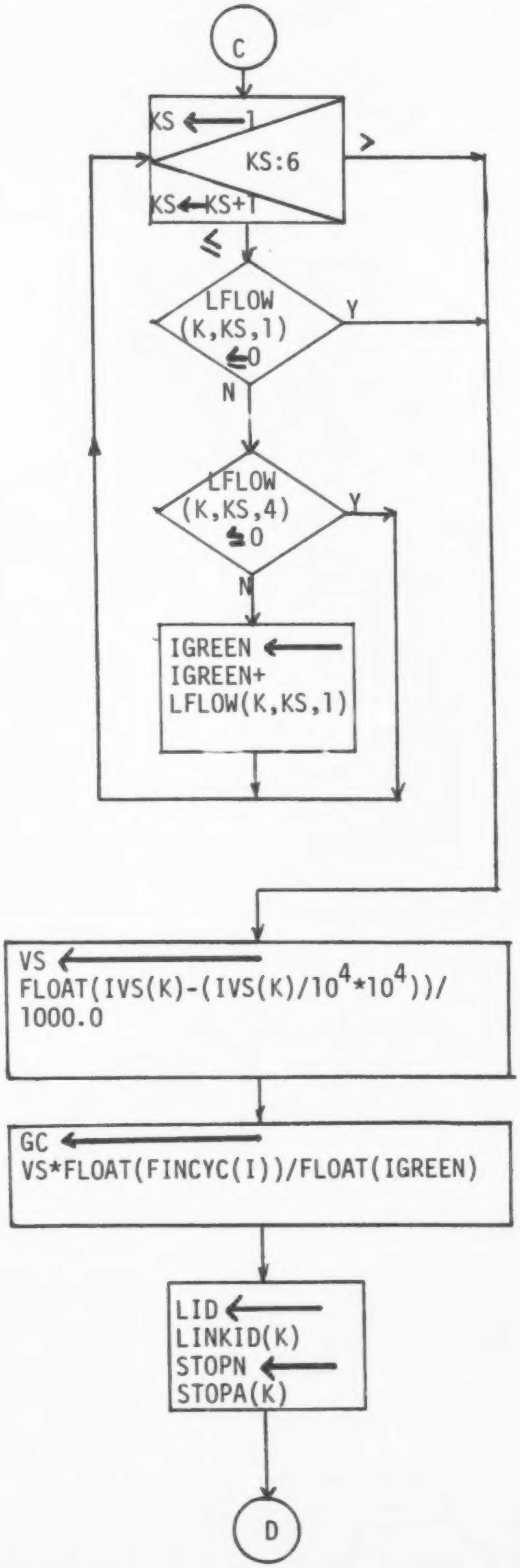

F
L ← 1
L:N1
L ← L+1
>
≤
EE(L,NXN)
← 0.0
K ← 1
K:IX
K ← K+1
>
≤
I ← INDEX(K)
J ← JNDEX(K)
Y
I = L
N
J ≠ L
Y
N
J ← I
EE(L,L) ←
EE(L,L)+A(K)
EE(L,J) ←
EE(L,J)-A(K)
INVERT
MATRIX
COMPUTE
G-ELEMENTS
TRANSFORM
TO STARTING
POINT
OPTIMIZE IN
GIVEN
REGION
TRANSFORM
TO LOCAL
OPTIMUM
SEARCH FOR
NEIGHBOURING
OPTIMA
COMPUTE &
STANDARDIZE
FINAL DELAY
RETURN

FTABLE

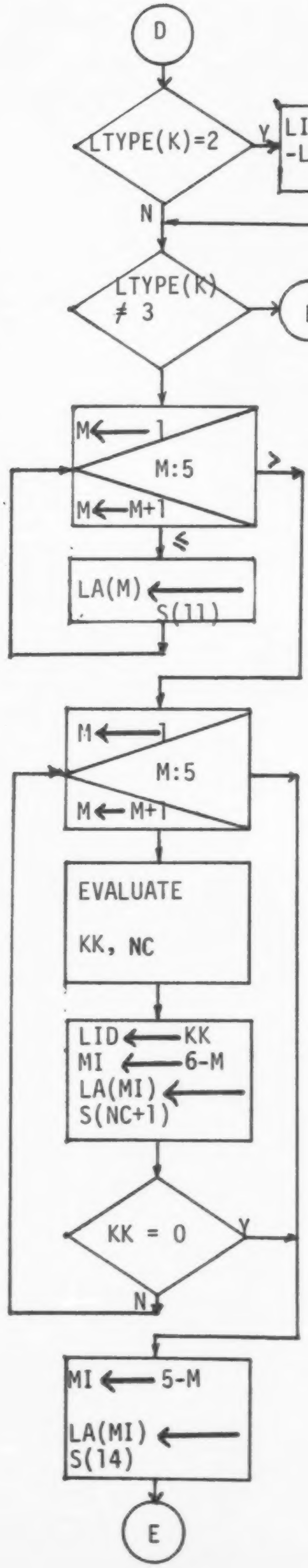

FTABLE
INITIALIZE VARIABLES
WRITE PAGE HEADING
ICYCLE ← NGOODC
J ← 1
J:NN
J ← J+1
>
≤
OFFSET(J) ← NGOODO(J)
OFFSET(J)=-1
Y
OFFSET(J) ← 0
N
OFF-SET(J) ≥ ICYCLE
Y
OFFSET(J) ← 0
N
J ← 1
J:NN
J ← J+1
>
≤
NGOODO(J) ≠ -1
Y
FINCYC(J) ← ICYCLE
N
FINCYC(J) < ICYCLE
Y
FINCYC(J) ← ICYCLE
II ← 1
I ← 1
I:NN
I ← I+1
N
>
A
≤
I < NN
Y
JJ ← LTDEX(I+1)-1
N
I=NN
Y
JJ ← NL
N
I > 1
Y
II ← LTDEX(I)
N
B

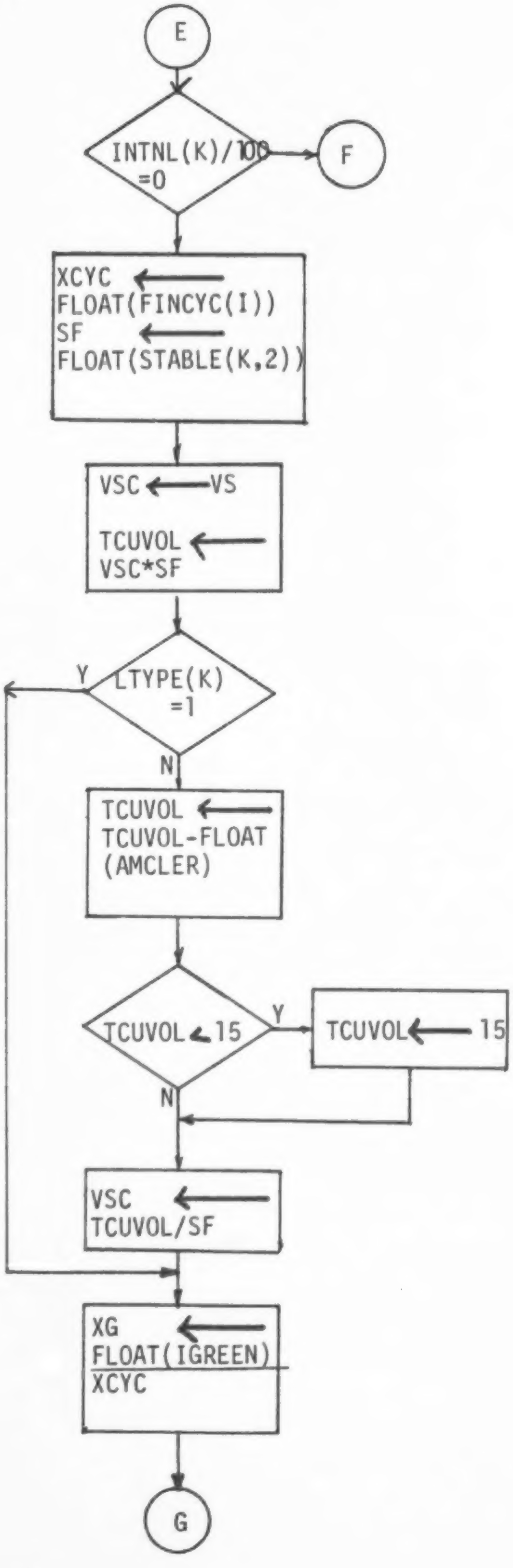
FTABLE


B
LCHECK ← JJ-II+2
LINEC+LCHECK ≤55
Y
N
WRITE NEW PAGE HEADING
LINEC ← LINEC+LCHECK
K ← II-1
M
K ← K+1
KSL ← STDEX(K)
KSU ← STDEX(K)+ ACTIVE(K)-1
IGREEN ← 0
C

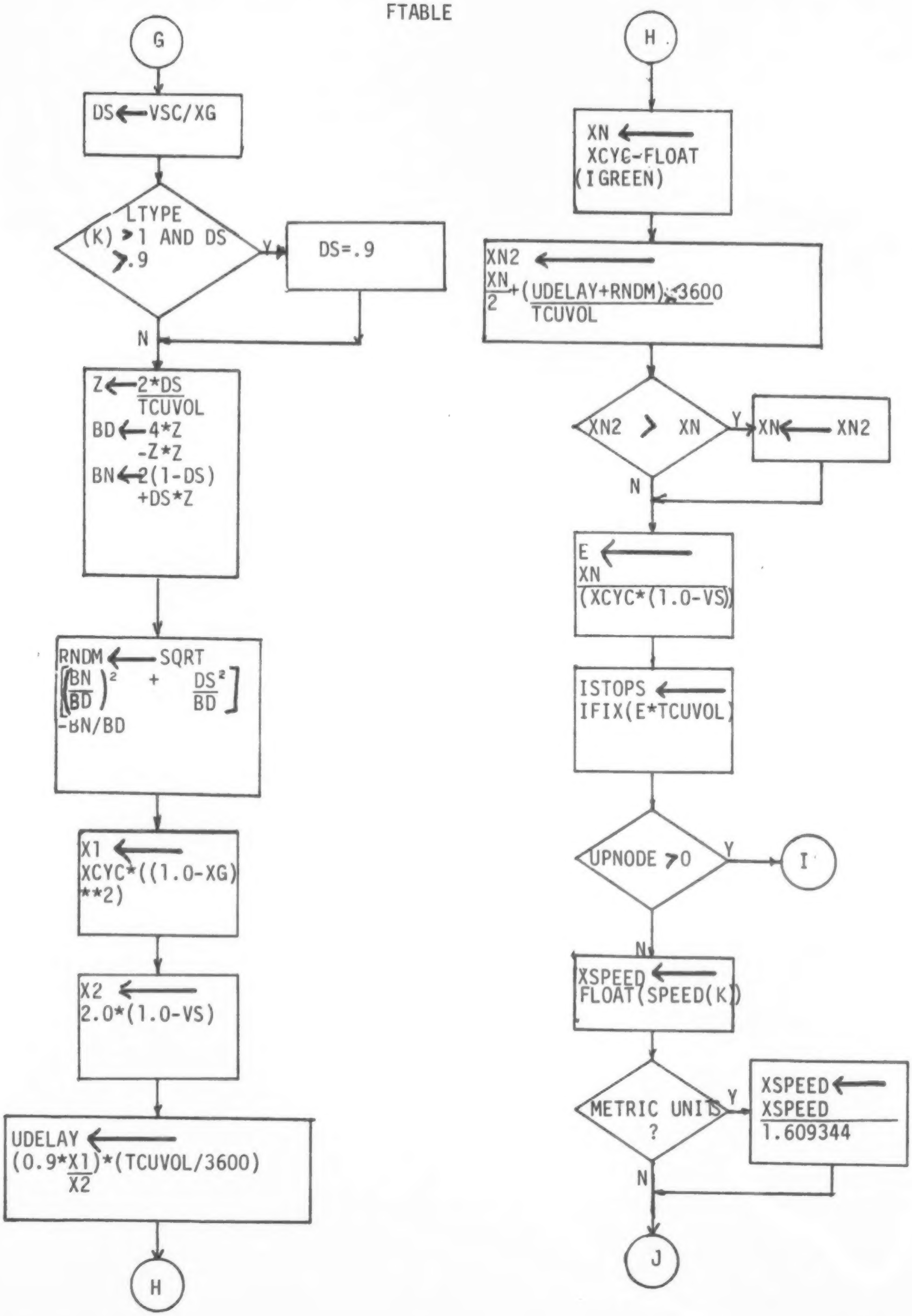

C
KS ← 1
KS:6
KS ← KS+1
>
≤
LFLOW (K,KS,1) ≤0
Y
N
LFLOW (K,KS,4) ≤0
Y
N
IGREEN ← IGREEN+ LFLOW(K,KS,1)
VS ← FLOAT(IVS(K)-(IVS(K)/10^4*10^4))/ 1000.0
GC ← VS*FLOAT(FINCYC(I))/FLOAT(IGREEN)
LID ← LINKID(K)
STOPN ← STOPA(K)
D

FTABLE

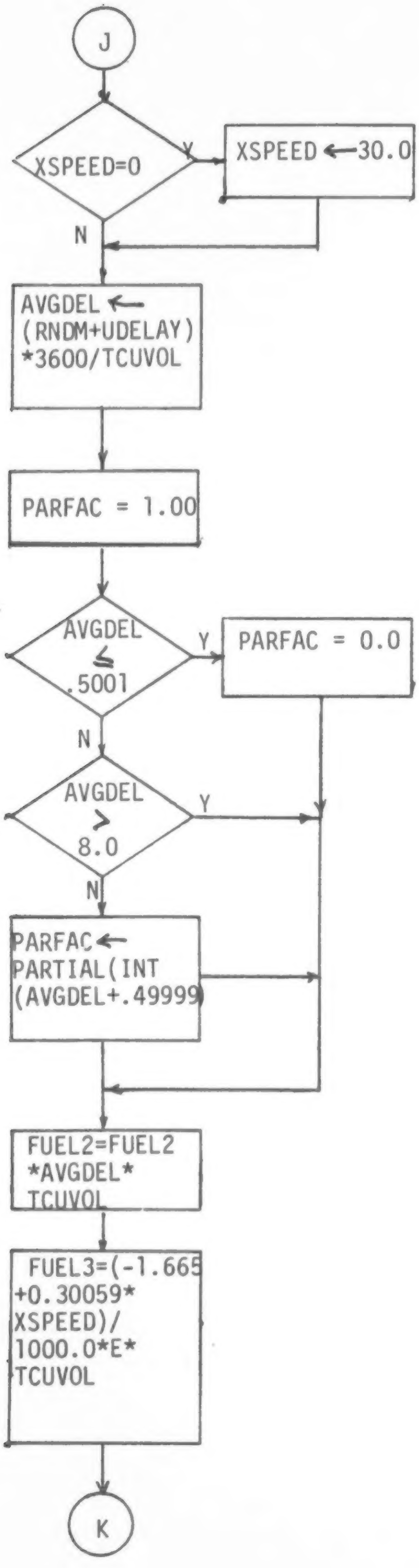

D
LTYPE(K)=2
Y
LID ←
-LINKID(K)
N
LTYPE(K)
≠ 3
E
M ← 1
M:5
M ← M+1
>
≤
LA(M) ←
S(11)
M ← 1
M:5
M ← M+1
EVALUATE
KK, NC
LID ← KK
MI ← 6-M
LA(MI) ←
S(NC+1)
KK = 0
Y
N
MI ← 5-M
LA(MI) ←
S(14)
E

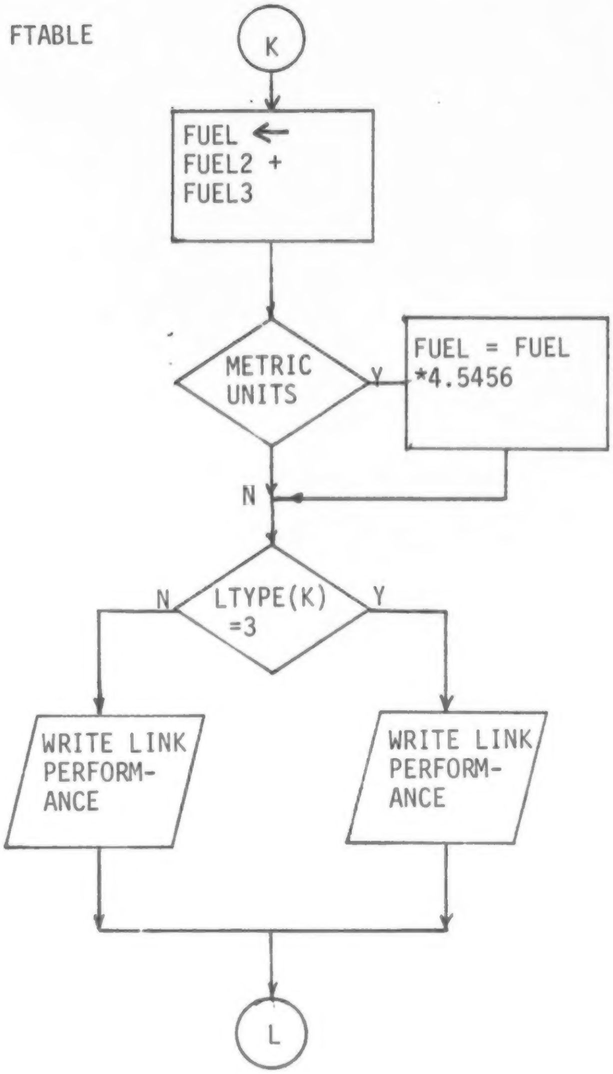

E
INTNL(K)/100
=0
F
XCYC ←
FLOAT(FINCYC(I))
SF ←
FLOAT(STABLE(K,2))
VSC ← VS
TCUVOL ←
VSC*SF
Y
LTYPE(K)
=1
N
TCUVOL ←
TCUVOL-FLOAT
(AMCLER)
TCUVOL < 15
Y
TCUVOL ← 15
N
VSC ←
TCUVOL/SF
XG ←
FLOAT(IGREEN)
XCYC
G

FTABLE

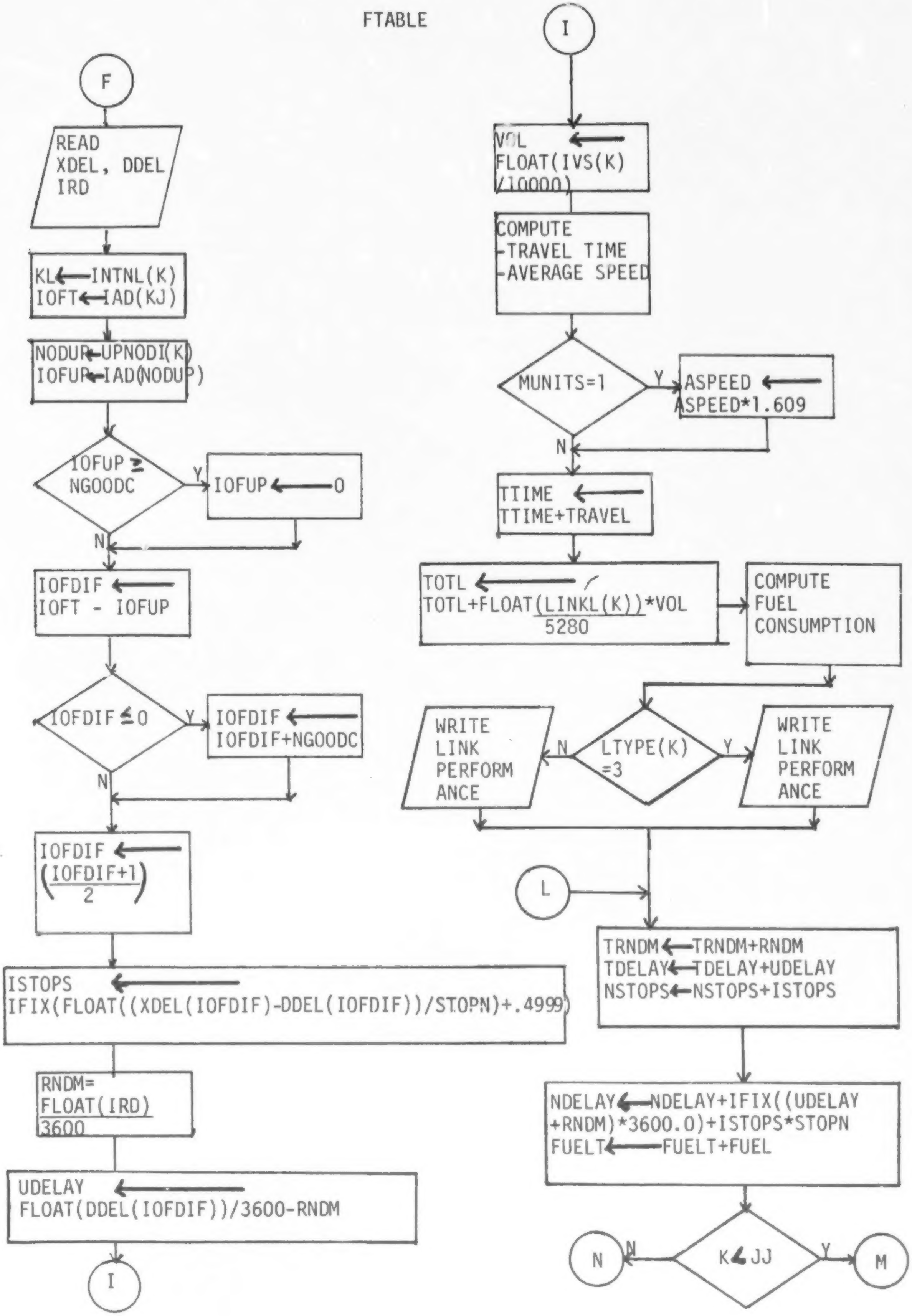

G
DS ← VSC/XG
LTYPE (K) > 1 AND DS > .9
Y
DS=.9
N
Z ← 2*DS / TCUVOL
BD ← 4*Z -Z*Z
BN ← 2(1-DS) +DS*Z
RNDM ← SQRT [(BN/BD)² + DS²/BD] -BN/BD
X1 ← XCYC*((1.0-XG) **2)
X2 ← 2.0*(1.0-VS)
UDELAY ← (0.9*X1/X2)*(TCUVOL/3600)
H
H
XN ← XCYC-FLOAT (IGREEN)
XN2 ← XN/2 + (UDELAY+RNDM)*3600 / TCUVOL
XN2 > XN
Y
XN ← XN2
N
E ← XN / (XCYC*(1.0-VS))
ISTOPS ← IFIX(E*TCUVOL)
UPNODE > 0
Y
I
N
XSPEED ← FLOAT(SPEED(K))
METRIC UNITS ?
Y
XSPEED ← XSPEED / 1.609344
N
J

FTABLE

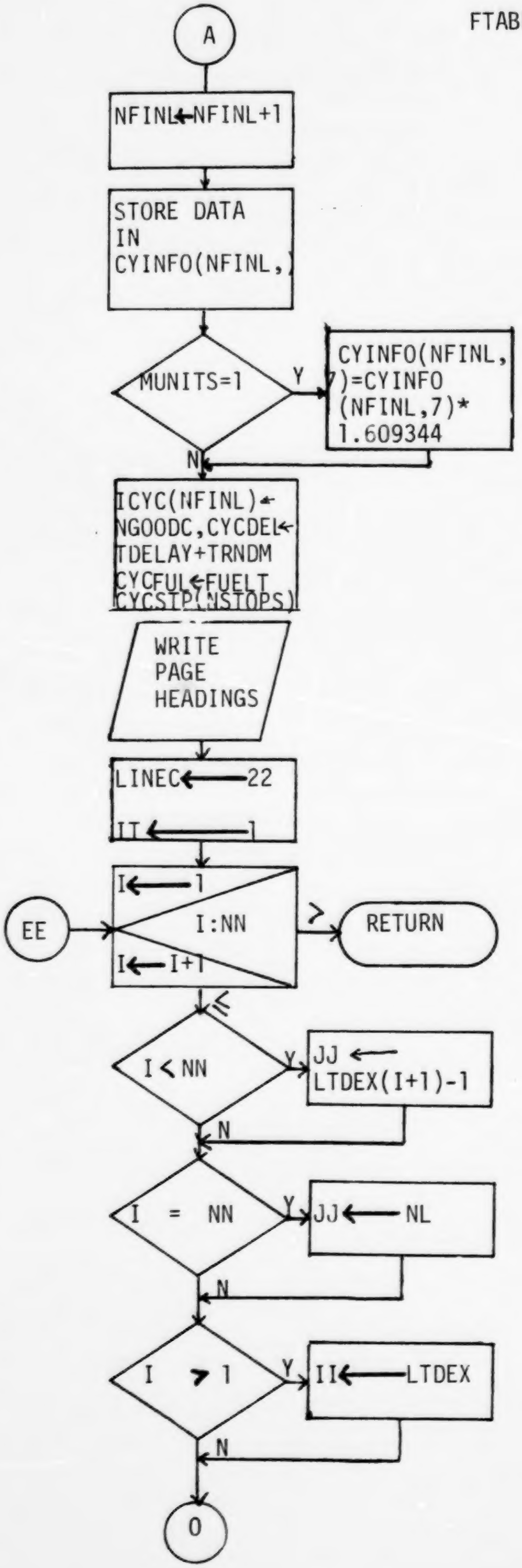

J
XSPEED=0
Y
XSPEED ←30.0
N
AVGDEL ← (RNDM+UDELAY) *3600/TCUVOL
PARFAC = 1.00
AVGDEL ≦ .5001
Y
PARFAC = 0.0
N
AVGDEL > 8.0
Y
N
PARFAC ← PARTIAL(INT (AVGDEL+.49999)
FUEL2=FUEL2 *AVGDEL* TCUVOL
FUEL3=(-1.665 +0.30059* XSPEED)/ 1000.0*E* TCUVOL
K

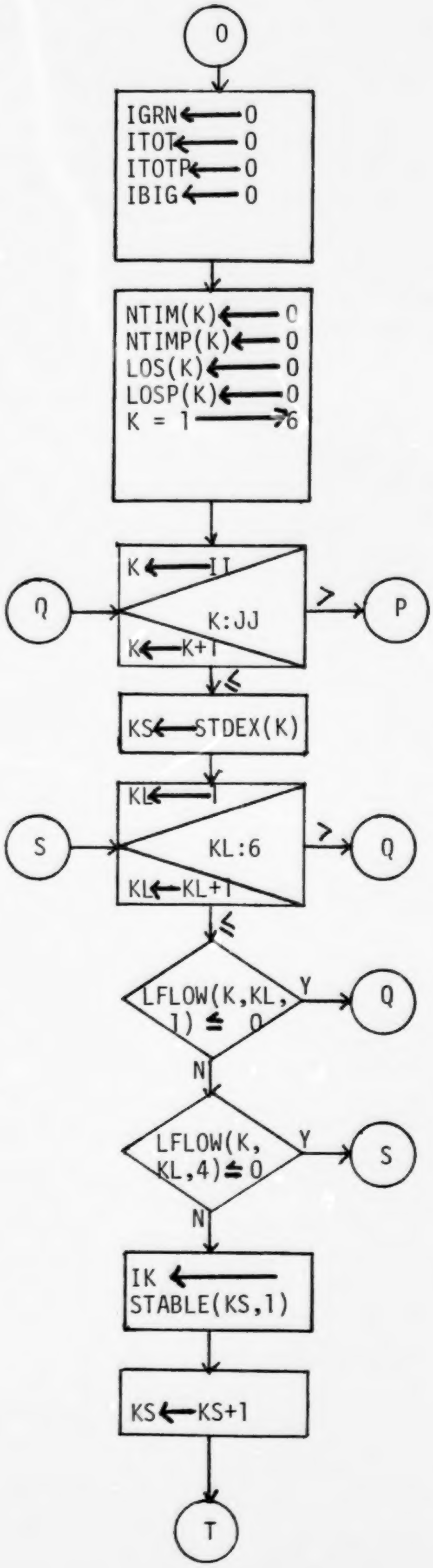

K
FUEL ← FUEL2 + FUEL3
METRIC UNITS
Y
FUEL = FUEL *4.5456
N
LTYPE(K) =3
N
Y
WRITE LINK PERFORM-ANCE
WRITE LINK PERFORM-ANCE
L

FTABLE

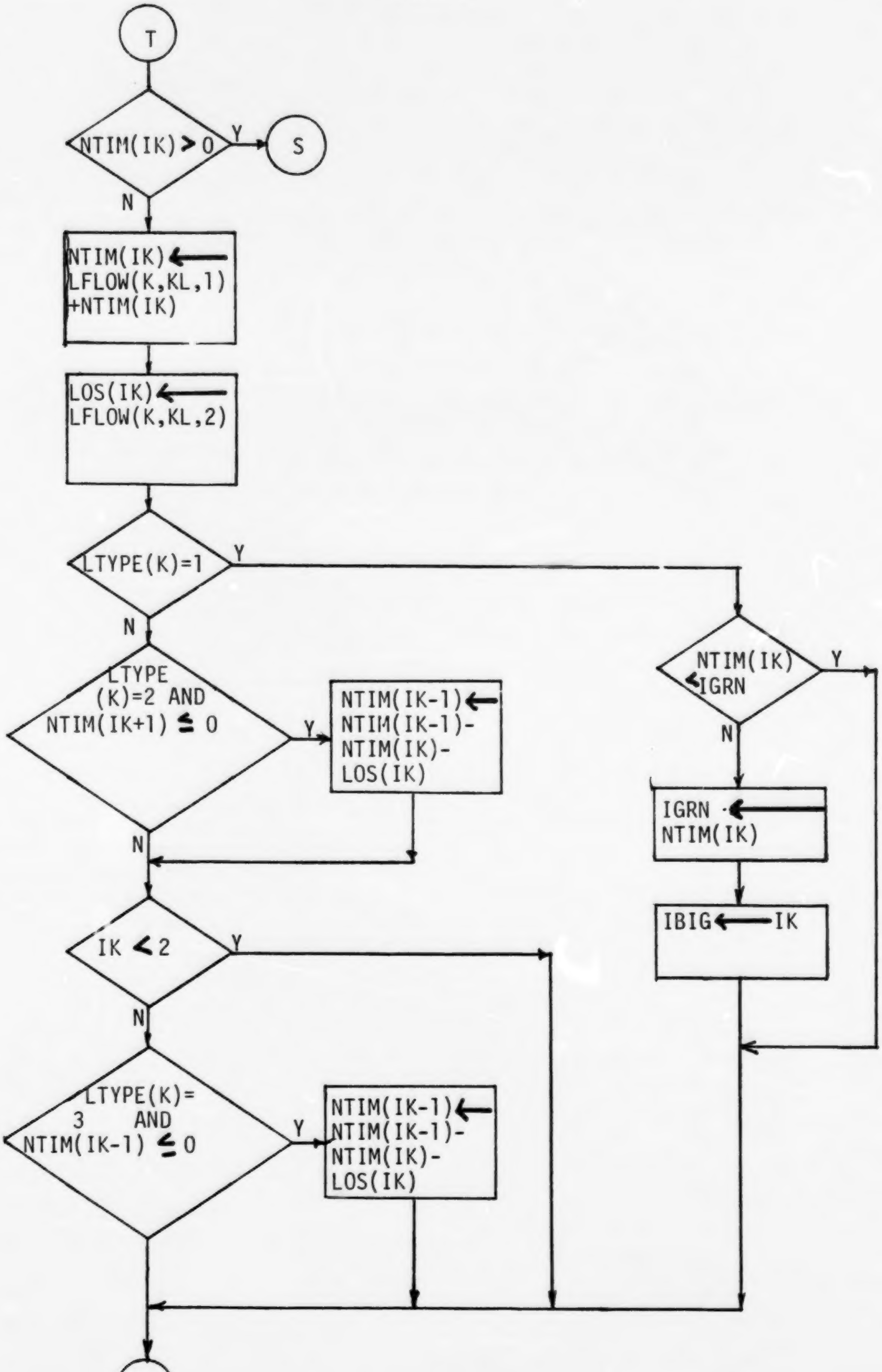

F
READ
XDEL, DDEL
IRD
KL←INTNL(K)
IOFT←IAD(KJ)
NODUP←UPNODI(K)
IOFUP←IAD(NODUP)
IOFUP ≥ NGOODC
Y
IOFUP ←0
N
IOFDIF ← IOFT - IOFUP
IOFDIF ≤ 0
Y
IOFDIF ← IOFDIF+NGOODC
N
IOFDIF ← ((IOFDIF+1)/2)
ISTOPS ← IFIX(FLOAT((XDEL(IOFDIF)-DDEL(IOFDIF))/STOPN)+.4999)
RNDM= FLOAT(IRD)/3600
UDELAY ← FLOAT(DDEL(IOFDIF))/3600-RNDM
I
I
VOL ← FLOAT(IVS(K)/10000)
COMPUTE
-TRAVEL TIME
-AVERAGE SPEED
MUNITS=1
Y
ASPEED ← ASPEED*1.609
N
TTIME ← TTIME+TRAVEL
TOTL ← TOTL+FLOAT(LINKL(K))/5280*VOL
COMPUTE
FUEL
CONSUMPTION
LTYPE(K) =3
N
WRITE
LINK
PERFORM
ANCE
Y
WRITE
LINK
PERFORM
ANCE
L
TRNDM←TRNDM+RNDM
TDELAY←TDELAY+UDELAY
NSTOPS←NSTOPS+ISTOPS
NDELAY←NDELAY+IFIX((UDELAY+RNDM)*3600.0)+ISTOPS*STOPN
FUELT←FUELT+FUEL
K ≤ JJ
N
N
Y
M

FTABLE

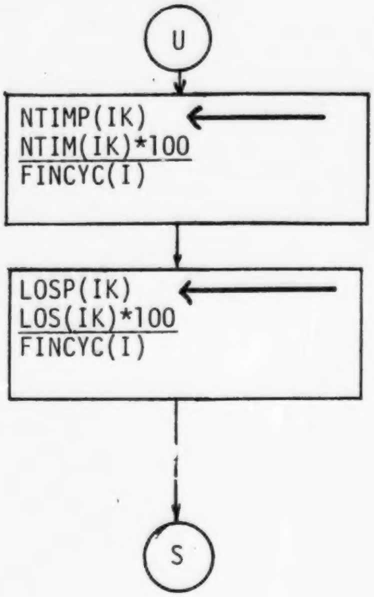

A
NFINL←NFINL+1
STORE DATA IN CYINFO(NFINL,)
MUNITS=1
Y
CYINFO(NFINL,7)=CYINFO(NFINL,7)*1.609344
N
ICYC(NFINL)←NGOODC,CYCDEL←TDELAY+TRNDM
CYCFUL←FUELT
CYCSTP(NSTOPS)
WRITE PAGE HEADINGS
LINEC←22
II←1
EE
I←1
I:NN
I←I+1
>
RETURN
≤
I < NN
Y
JJ ← LTDEX(I+1)-1
N
I = NN
Y
JJ←NL
N
I > 1
Y
II←LTDEX
N
O


O
IGRN←0
ITOT←0
ITOTP←0
IBIG←0
NTIM(K)←0
NTIMP(K)←0
LOS(K)←0
LOSP(K)←0
K = 1→6
Q
K←II
K:JJ
K←K+1
>
P
≤
KS←STDEX(K)
S
KL←1
KL:6
KL←KL+1
>
Q
≤
LFLOW(K,KL,1) ≤ 0
Y
Q
N
LFLOW(K,KL,4) ≤ 0
Y
S
N
IK ← STABLE(KS,1)
KS←KS+1
T

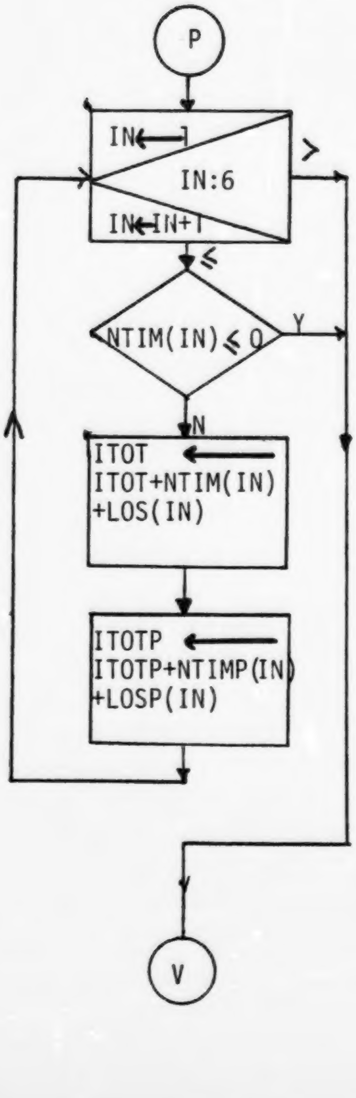
FTABLE


T
NTIM(IK) > 0
Y
S
N
NTIM(IK) ← LFLOW(K,KL,1) +NTIM(IK)
LOS(IK) ← LFLOW(K,KL,2)
LTYPE(K)=1
Y
N
LTYPE (K)=2 AND NTIM(IK+1) ≤ 0
Y
NTIM(IK-1) ← NTIM(IK-1)- NTIM(IK)- LOS(IK)
N
NTIM(IK) < IGRN
Y
N
IGRN ← NTIM(IK)
IBIG ← IK
IK < 2
Y
N
LTYPE(K)= 3 AND NTIM(IK-1) ≤ 0
Y
NTIM(IK-1) ← NTIM(IK-1)- NTIM(IK)- LOS(IK)
U

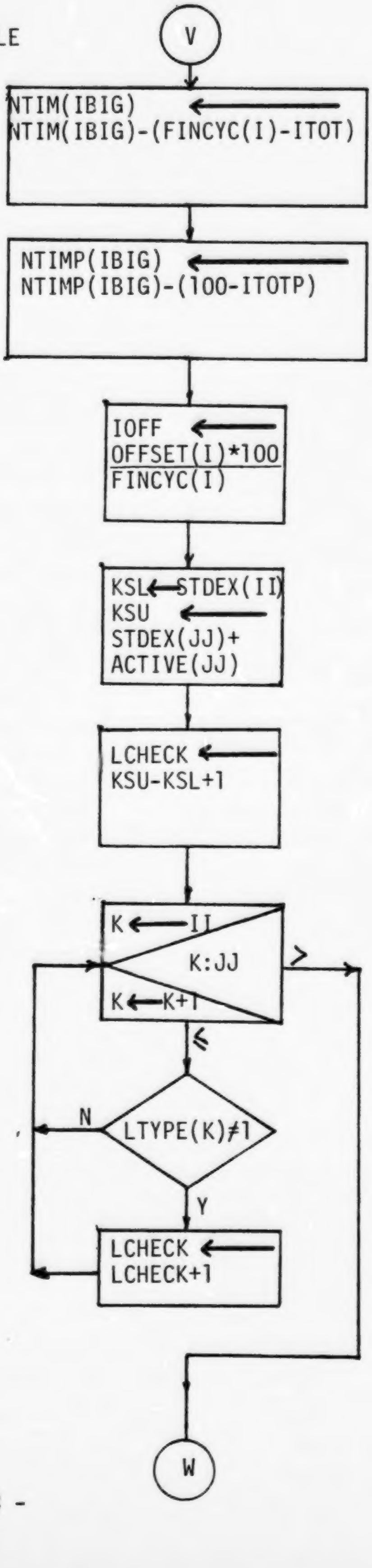
FTABLE



U
NTIMP(IK) ← NTIM(IK)*100 / FINCYC(I)
LOSP(IK) ← LOS(IK)*100 / FINCYC(I)
S

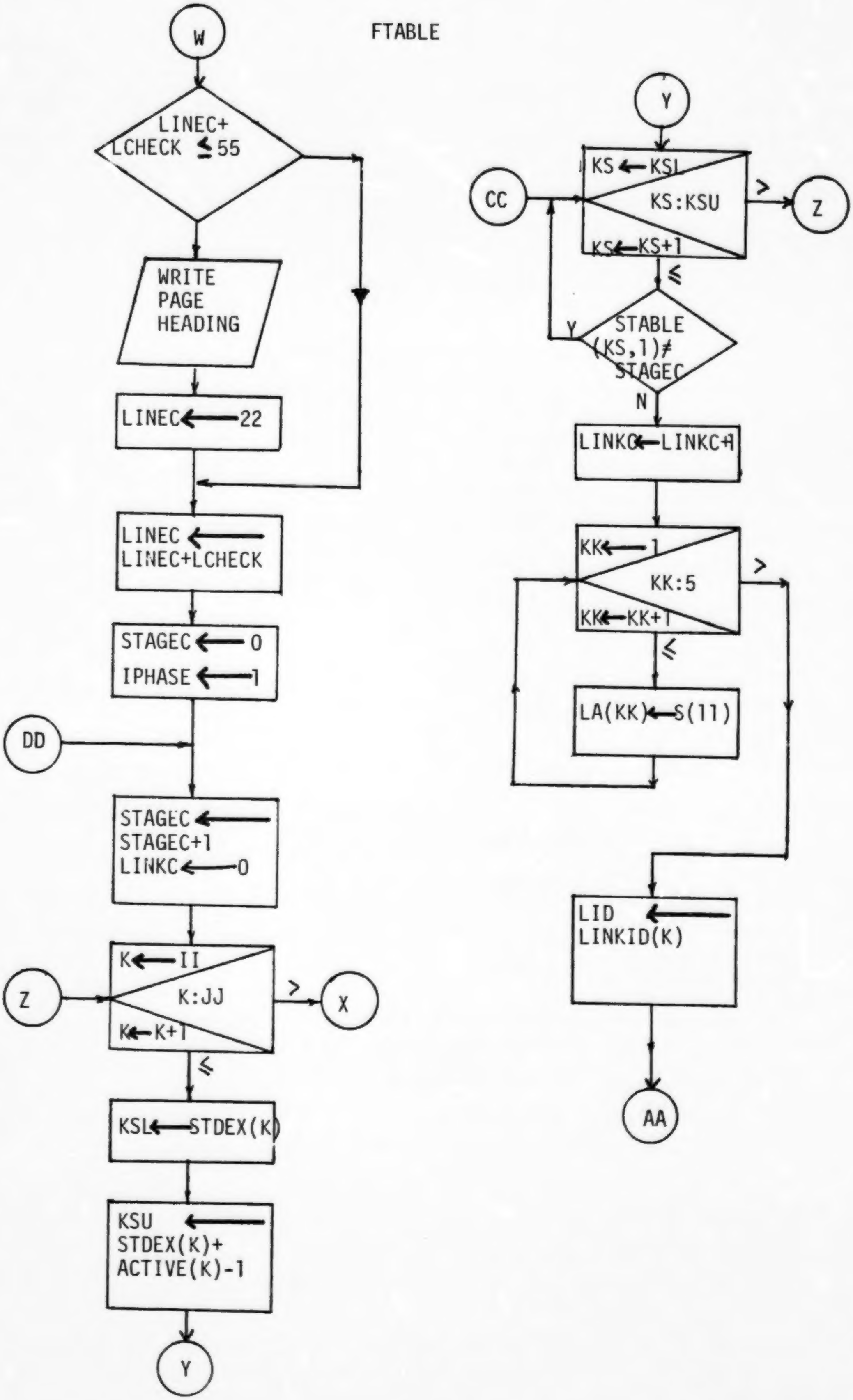


P
IN ← 1
IN:6
IN ← IN+1
>
≤
NTIM(IN) ≤ 0
Y
N
ITOT ← ITOT+NTIM(IN) +LOS(IN)
ITOTP ← ITOTP+NTIMP(IN) +LOSP(IN)
V

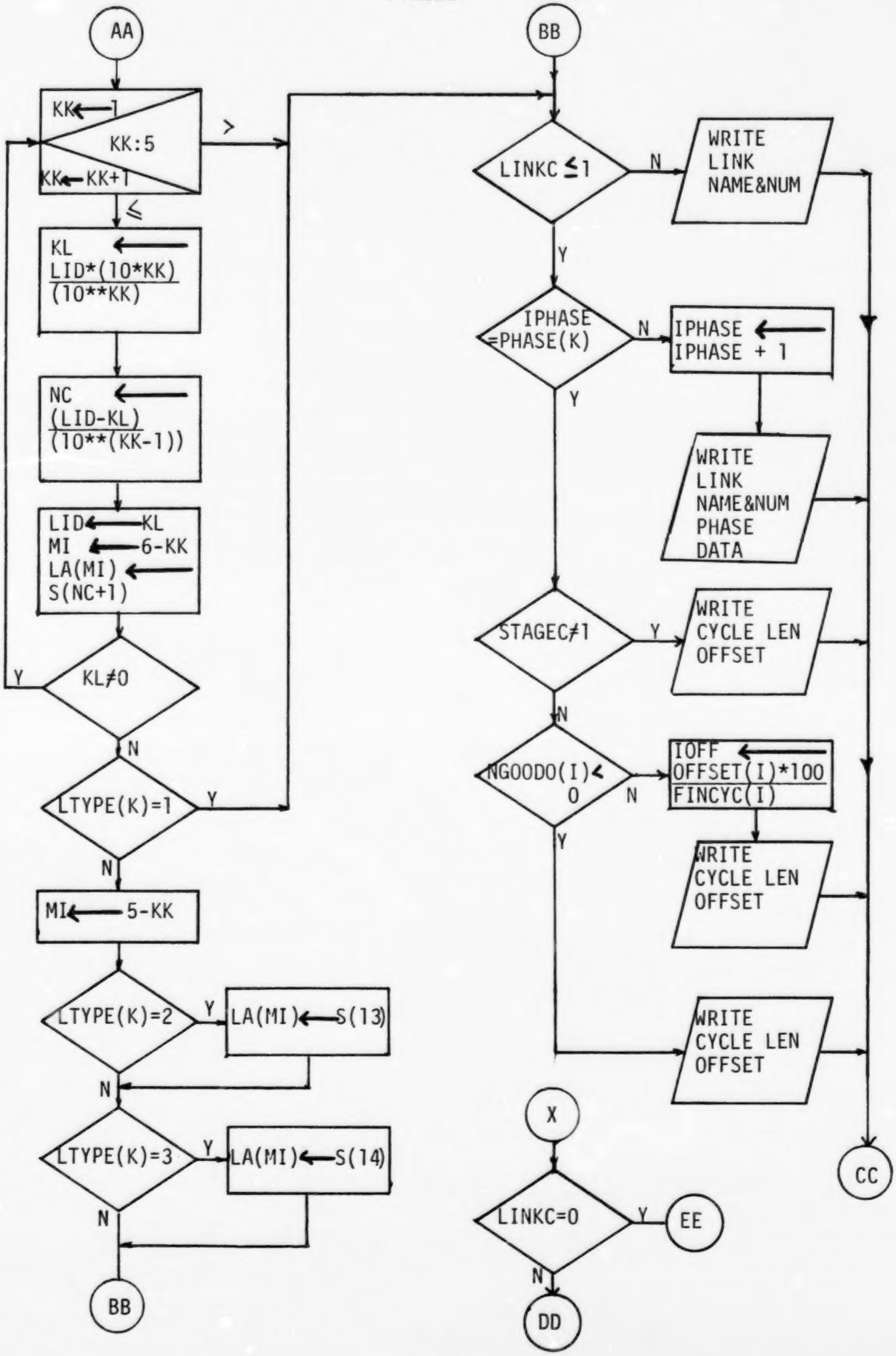


V
NTIM(IBIG) ← NTIM(IBIG)-(FINCYC(I)-ITOT)
NTIMP(IBIG) ← NTIMP(IBIG)-(100-ITOTP)
IOFF ← OFFSET(I)*100 / FINCYC(I)
KSL ← STDEX(II)
KSU ← STDEX(JJ)+ ACTIVE(JJ)
LCHECK ← KSU-KSL+1
K ← II
K:JJ
K ← K+1
>
≤
LTYPE(K)≠1
N
Y
LCHECK ← LCHECK+1
W

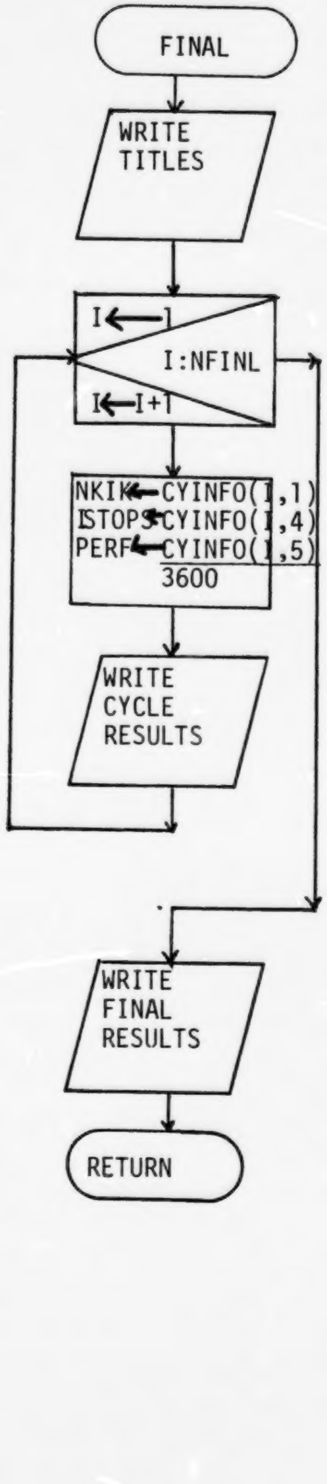
FTABLE


W
LINEC+
LCHECK ≤ 55
WRITE
PAGE
HEADING
LINEC ← 22
LINEC ←
LINEC+LCHECK
STAGEC ← 0
IPHASE ← 1
DD
STAGEC ←
STAGEC+1
LINKC ← 0
Z
K ← II
K:JJ
K ← K+1
>
X
≤
KSL ← STDEX(K)
KSU ←
STDEX(K)+
ACTIVE(K)-1
Y
Y
CC
KS ← KSL
KS:KSU
KS ← KS+1
>
Z
≤
Y
STABLE
(KS,1)≠
STAGEC
N
LINKC ← LINKC+1
KK ← 1
KK:5
KK ← KK+1
>
≤
LA(KK) ← S(11)
LID ←
LINKID(K)
AA

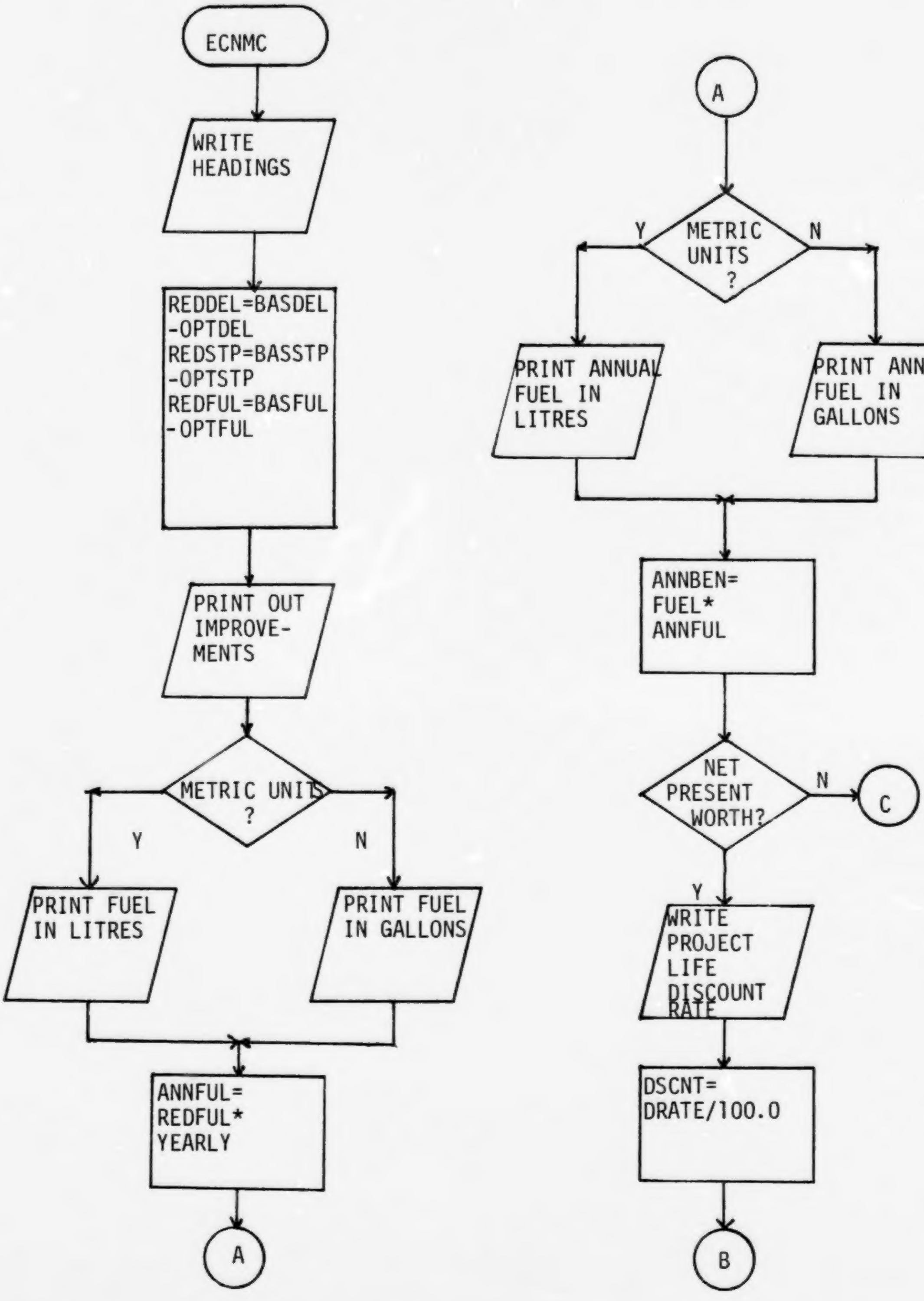
FTABLE


AA
KK ← 1
KK:5
KK ← KK+1
>
≤
KL ← LID*(10*KK)/(10**KK)
NC ← (LID-KL)/(10**(KK-1))
LID ← KL
MI ← 6-KK
LA(MI) ← S(NC+1)
KL≠0
Y
N
LTYPE(K)=1
Y
N
MI ← 5-KK
LTYPE(K)=2
Y
LA(MI) ← S(13)
N
LTYPE(K)=3
Y
LA(MI) ← S(14)
N
BB
BB
LINKC ≤ 1
N
WRITE LINK NAME&NUM
Y
IPHASE =PHASE(K)
N
IPHASE ← IPHASE + 1
WRITE LINK NAME&NUM PHASE DATA
Y
STAGEC≠1
Y
WRITE CYCLE LEN OFFSET
N
NGOODO(I)< 0
N
IOFF ← OFFSET(I)*100/FINCYC(I)
WRITE CYCLE LEN OFFSET
Y
WRITE CYCLE LEN OFFSET
CC
X
LINKC=0
Y
EE
N
DD

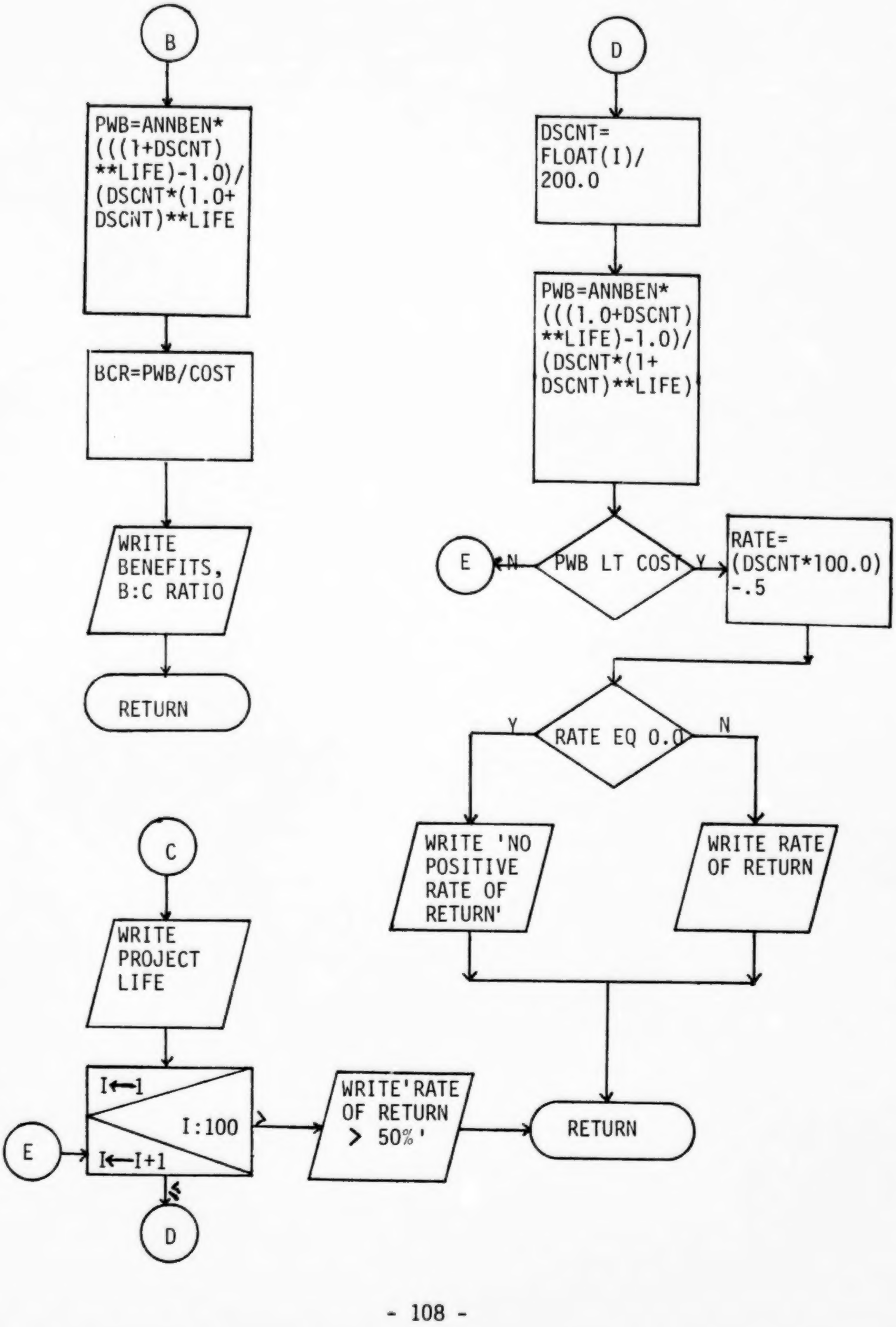
FINAL


FINAL
WRITE TITLES
I←1
I:NFINL
I←I+1
NKIK←CYINFO(I,1)
ISTOPS←CYINFO(I,4)
PERF←CYINFO(I,5)/3600
WRITE CYCLE RESULTS
WRITE FINAL RESULTS
RETURN

ECNMC


ECNMC
WRITE HEADINGS
REDDEL=BASDEL -OPTDEL REDSTP=BASSTP -OPTSTP REDFUL=BASFUL -OPTFUL
PRINT OUT IMPROVEMENTS
METRIC UNITS ?
Y
N
PRINT FUEL IN LITRES
PRINT FUEL IN GALLONS
ANNFUL= REDFUL* YEARLY
A
A
METRIC UNITS ?
Y
N
PRINT ANNUAL FUEL IN LITRES
PRINT ANNUAL FUEL IN GALLONS
ANNBEN= FUEL* ANNFUL
NET PRESENT WORTH?
N
C
Y
WRITE PROJECT LIFE DISCOUNT RATE
DSCNT= DRATE/100.0
B

ECNMC


B
PWB=ANNBEN*
(((1+DSCNT)
**LIFE)-1.0)/
(DSCNT*(1.0+
DSCNT)**LIFE
BCR=PWB/COST
WRITE
BENEFITS,
B:C RATIO
RETURN
D
DSCNT=
FLOAT(I)/
200.0
PWB=ANNBEN*
(((1.0+DSCNT)
**LIFE)-1.0)/
(DSCNT*(1+
DSCNT)**LIFE)
E
N
PWB LT COST
Y
RATE=
(DSCNT*100.0)
-.5
Y
RATE EQ 0.0
N
WRITE 'NO
POSITIVE
RATE OF
RETURN'
WRITE RATE
OF RETURN
C
WRITE
PROJECT
LIFE
I←1
I:100
E
I←I+1
>
≤
D
WRITE'RATE
OF RETURN
> 50%'
RETURN